경영학석사학위논문

Investment performance of Common stocks in relation to their PTR

-For KOSPI and KOSDAQ common stocks, simulated stock investment

PTR 에 따른 주식의 투자성과 연구

-KOSPI 와 KOSDAQ 상장주 투자 시뮬레이션

2016 년 2 월

서울대학교 대학원

경영학과 생산관리전공

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지도교수 오 정 석

이 논문을 경영학 석사학위논문으로 제출함

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전 가 영

전가영의 석사학위논문을 인준함

2016 년 2 월

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Abstract

It is widely understood that the Research and development (R&D) is an investment activity. And the output is an intangible asset that should be reflected in the observed market value of the firm. Bosworth, D. and Rogers, M suggested in their work that R&D and patent activity are positively and significantly associated with market value. Also, K.-C. Chang et al. (2012) showed patents are widely adopted in research concerning relationship between patent counts and corporation performance.

In research regarding the relationship between patent performance and corporation performances, many scholars have confirmed the positive relation between patent citations and market value of firm. We suggest one another indicator PTR, which evaluates the firm's technology value. The technology value includes firm's patented R&D output and patents the firm possessed by purchase. Accordingly, low PTR means that the

value of firm's R&D activity is not fully reflected in security prices and investing portfolios with low PTR stocks will result in high investment performance. In the simulation of long term investment, there was a size effect.

The findings of this study confirmed the PTR portfolios outperform the PER portfolios. Therefore managers should consider PTR and technology value when they make investment decisions. Especially, firms between market value of 50 to 100 billion KRW should consider PTR. Due to the size effect, considering technology value is more proper for those firms.

Key words : patent value; patent-technology ratio; research and development output indicator; patent value indicator.

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1. Introduction

It is widely understood that the Research and development (R&D) is an investment activity, the output of which is an intangible asset that can be labeled as the firm's "knowledge stock".(Hall, B. H., Jaff, A. and Trajtenberg, M., 2005). K.-C. Chang et al. (2012) showed patents, serve as an important output indicator of research and development activities, are widely adopted in researches concerning relationship between patent counts and corporation performance. Schankerman, M. and Pakes, A. (1986) empirically tested the value of the benefits derived from the patent.

And they demonstrated that the distribution of patent rights' private value is sharply skewed. Hall, Jaffe, and Trajtenberg provided evidence that the intensity of citations of companies' patents is also associated with their market values. In research regarding the relationship between patent performance and corporation performances, many scholars have confirmed the positive relation between patent citations and market value of firm.

Deng et al. (1999) empirical study confirmed that the higher patent counts and patent citations are, the better corporation performance (stock return, market-to-book ratio) is. Besides, findings of Harhoff, Narin, Scherer, and Vopel (1999), and Harhoff, Scherer, and Vopeld (2003) also suggested positive relation between patent value and patent citations.

We suggest PTR as an indicator to measure the patent value. PTR is defined as market value divided by technology value. The technology value means the integration of patented R&D output and patents the firm possessed by purchase. Thus, PTR is an indicator which can be used to evaluate whether the firm's technology value is properly reflected in the market value.

Low PTR means those technology value of company is underestimated. Therefore, by investing the portfolio consisted of low PTR stock items will result high returns. S. Basu (1977) empirically showed low PER portfolios did earn superior returns. The result of this study show that the PTR portfolios outperform the PER portfolios.

The remainder of this paper is organized as follows. In section 2, the literature related to this study is reviewed. Section 3 describes the research methodology. Section 4 presents the results of simulation and actual investment. The paper concludes with Section 5.

2. Literature review

Research and Development (R&D) conducted by private firms is an investment activity. The output of R&D is an intangible asset which can be called the firm's "Knowledge stock". Because this activity contributes positively to the firm's future net cash flows, the value of this knowledge stock should be reflected in the observed market value of the firm (Hall, B. H., Jaffe, A. and Trajtenberg, M., 2005).

There are several studies that explain the role of patents as an output indicator of R&D activities. Brosworth, D. and Rogers, M. considered the value of innovation to large Australian firms. Specifically, they investigated how R&D and intellectual property activity influences the market value of firms, using a Tobin's q approach. The findings suggested that R&D and patent activity are positively and significantly associated with market value. F.M. Scherer showed that an inventive output is positively correlated with the growth of corporate profits in 448 firms appearing on Fortune's list of 500 largest U.S. industrial corporations in 1955.

These studies show the positive relationship between patent counts and firm performance.

However, patent counts is not sufficient to offer information regarding innovation output because of difference in patent's value. Some enterprises may have only a small number of patents but with high influence, while others may have many patents yet low in influence. This phenomenon is also known as the skewed distribution of patent value which means that patents with high value and high influence only take a small portion of total patents.(K-C, Chang et al., 2012) Therefore, simple patent count cannot be seen as a suitable measure of innovation activity (R&D).

The following studies attempted to resolve the value-heterogeneity problem in measuring patent stock. Schankerman, M. and Pakes, A. (1986) empirically tested the value of the benefits derived from the patent. And demonstrated that the distribution of the private value of patent rights is sharply skewed in the United Kingdom, France and Germany. There are a lot of patent rights with low economic value, but the tail of the distribution contains highly valuable patent rights.

Many scholars suggest that the patent citations could be used to measure the influence of patent. The idea of measuring patent citations is based on the same way in Bibliometrics that the influence of certain publication could be measured by its citation. So that patent citations could also be used to measure the quality and the influence of patents. By conducting patent citation analysis, fundamental or important patents can be identified (K.-C. Chang et al., 2012).

In studies regarding the relationship between patent performance and corporation performances, many scholars have confirmed the positive relation between patent citations and market value. At the same time, patent citations is also highly interrelated with profits and sales. Deng et al. (1999) empirically confirmed that the higher patent counts and patent citations are, the better corporation performance(stock return, market-to-book ratio) is. Also, Harhoff, Narin, Scherer, and Vopel (1999) and Harhoff, Schererec, and Vopeld (2003) suggest positive relation between patent value and patent citations. Therefore, we can draw

the conclusion that high patent citations also reflects high economic value.

Chen and Chang studied the relationship between corporate market value and four patent quality indicators – relative patent position (RPP), revealed technology advantage (RTA), Herfindahl–Hirschman Index of patents (HHI of patents), and patent citations – in US pharmaceutical industry. The results showed that patent citations were positively associated with corporate market value. Using patent citation and other patent quality indicators to measure the influence of patent can be useful, but we suggest PTR (Price to Technology Ratio) as a new indicator to measure the influence of patent. We can suggest it by comparing the investment performance based on PTR and KOSPI (Korea Composite Stock Price Index).

PTR is defined as market value divided by technology value. In PTR, the technology value means the integration of patented R&D output and patents the firm possessed by purchase. PTR is an indicator of the future investment performance of a security. The numerator of PTR was defined as the market value of common

stock and the denominator as technology value. The technology value means the value of technology which is patented and Wizdomain used global patent price to measure the paten value.

$$PTR = \frac{\text{Aggregate Market Value}}{\Sigma \text{ Price of Patent}} = \frac{\text{Share Price}}{\text{TPS}}$$

*TPS: Technology-value Per Share

This is similar to PER(price-to-earnings ratio), or P/E ratio, an equity valuation multiple.

S. Basu (1977) empirically showed the investment performance of common stocks is related to their PER. Due to exaggerated investor expectations, PER can be an indicators of future investment performance. Portfolios consisted of low price-to-earnings ratios did earn superior returns. Low PER means the stock price is underestimated and indicates future investment performance higher than market average. In a similar way, we can suggest low PTR can get high investment performance. And by comparing the investment performance of portfolios consisted of

PER and PTR, we can show the role of PTR is an superior indicator of future investment performance than PER.

H1. PTR portfolios outperform than PER portfolios.

Rolf W. BANZ (1981) found that smaller firms have had higher risk adjusted returns, on average, than larger firms. It is called "size effect" and has been in existence for at least forty years. The size effect is not linear in the market value, the main effect occurs for very small firms. We suggest this size effect will also appear when we apply PTR.

H2. The PTR portfolio investment performance has a size effect.

3. Data and Methodology

The following research design was employed to examine the relationship between PTR and investment performance of securities. For any given period under consideration, portfolios consisting of securities with similar PTR are formed. We conduct a simulation of investment with these portfolios and the performance of portfolios is evaluated in terms of pre-specified measures.

As a test of high investment performance, we compared performance of low PTR portfolio to KOSPI and KOSDAQ bench mark (stocks with high correlation between PTR and ROR) in the same period. Wizdomain consisted a portfolio with low PTR securities and actually traded on Korea stock exchange. The data base and methodological details are now discussed.

3.1. Data base and sample selection criteria

The primary data for this study is drawn from WISEfn, which is a financial information provider, that includes stock price and PER of the Korea stock exchange between January 2010−August 2015. (700 stocks with high correlation between PTR and ROR) The value of patent can be measured in various ways but we used a statistical income approach method which is suggested by Wizdomain.

The portfolio is consisted of 20 stock items which meet the conditions. We invested same amount of money to each stock items consisting portfolios. And we made an assumption that the stock price is not affected by the trade of portfolios. Also we suppose buying and selling is conducted in adjusted closing price and there is no transaction fee.

3.2. Method of Analysis

Beginning with January 2010, the PTR of every sample stock was computed. These ratios were ranked and 20 stock items(firms) from the lower part were selected. Portfolios of PER is also consisted as same as PTR portfolios. And then we conducted a simulation of investment.

After consisting portfolios, we invested same amount to each stock items consisting portfolios. We consisted portfolios everyday(when the information of stock price is exists) from January 2010 to July 2015, we consisted 1372 portfolios. We measured the investment performance(rate of return) of period reflecting market fluctuation of each stock item of portfolios.

$$\text{Rate of Return} = \frac{\text{Aggregate Market Value}}{\text{Investment}}$$

The rate of return of portfolio and the probability of attaining target rate of return is computed monthly.

$$\text{The probability of attaining target ROR} = \frac{\text{Number of portfolios (meet the target)}}{\text{Total Number of the portfolios}}$$

And comparing the investment performance of portfolios consisted of PER and PTR.

Most of the portfolio selection procedures to consider the size effect are identical to the one described above. But the population is divided by the total market value. After forming portfolios to consider firm size, we conducted identical simulation to the one described above.

Finally, we analyzed actual investment of Wizdomain and compared the investment performance to KOSPI and KOSDAQ bench mark. Because the simulation comparing low PER and low PTR portfolios only considered upper side of investment, we considered both gain and loss by analyzing real investment. The portfolio was consisted with low PTR securities and actually traded on Korea stock exchange.

4. Results

4.1. Results of simulation comparing PER and PTR

Tables and figures below show the performance of portfolios consisted of bottom 20 PER and PTR stock items, as the target rate of return changes.

When the target rate of return(ROR) is 5%, the probability of attaining target ROR of PTR portfolio is higher than PER portfolio during the periods(from 1 to 24 months). To see this more clearly, a graph of probability of attaining target ROR appears in Figure 1.

When the target ROR is 10% and 15%, the probability of attaining target rate of return of PTR is superior in most of periods, Table 1 and Figure 2 shows the results of simulation when the target ROR is 10%. And Table 1 and Figure 3 shows the result of 15%. Also, there are results of simulation when the target ROR is 20% and 30%. The result shown in Table 1 and Figure 4, when the target ROR is 20% the result is similar to those

of 10% and 15%. But, the probability of attaining target ROR of PER is higher than PTR portfolios around 12 months. Further research is needed to explain this result.

However the results of 30% target ROR is different. The probability of attaining target goal of PTR portfolios is higher than PTR portfolios in every months. This is shown in Table 1 and Figure 5.

Table 1 Probability of attaining target ROR (5% to 30%)

Period (Months)	Probability of attaining target ROR (portfolio consisted of bottom 20)									
	5%		10%		15%		20%		30%	
	PTR	PER	PTR	PER	PTR	PER	PTR	PER	PTR	PER
1	0.50	0.43	0.19	0.16	0.09	0.02	0.03	0.00	0.00	0.00
2	0.71	0.60	0.39	0.37	0.23	0.18	0.15	0.05	0.05	0.00
3	0.80	0.68	0.54	0.47	0.35	0.30	0.22	0.16	0.12	0.02
4	0.84	0.71	0.64	0.52	0.48	0.37	0.32	0.25	0.18	0.06
5	0.88	0.75	0.70	0.56	0.54	0.41	0.42	0.28	0.25	0.10
6	0.90	0.79	0.76	0.61	0.60	0.45	0.46	0.32	0.31	0.11
7	0.92	0.83	0.78	0.68	0.67	0.52	0.53	0.36	0.38	0.11
8	0.93	0.87	0.80	0.73	0.69	0.58	0.58	0.40	0.45	0.13
9	0.94	0.89	0.81	0.76	0.72	0.65	0.61	0.46	0.49	0.13
10	0.94	0.91	0.83	0.81	0.75	0.70	0.64	0.51	0.52	0.15
11	0.95	0.93	0.85	0.85	0.77	0.76	0.67	0.57	0.54	0.20
12	0.95	0.95	0.86	0.90	0.79	0.82	0.69	0.64	0.55	0.24
13	0.96	0.95	0.89	0.91	0.79	0.84	0.69	0.69	0.56	0.32
14	0.96	0.95	0.91	0.91	0.81	0.84	0.70	0.69	0.57	0.38

15	0.98	0.95	0.93	0.91	0.82	0.84	0.69	0.71	0.59	0.44
16	0.98	0.95	0.94	0.92	0.83	0.84	0.71	0.72	0.61	0.48
17	0.98	0.95	0.94	0.92	0.85	0.84	0.74	0.75	0.63	0.51
18	0.98	0.95	0.95	0.92	0.88	0.85	0.78	0.77	0.66	0.55
19	0.98	0.95	0.96	0.92	0.90	0.87	0.81	0.81	0.68	0.58
20	0.99	0.96	0.99	0.93	0.93	0.88	0.84	0.84	0.69	0.63
21	1.00	0.98	1.00	0.94	0.97	0.89	0.89	0.85	0.72	0.68
22	1.00	0.99	1.00	0.96	0.99	0.91	0.93	0.87	0.75	0.71
23	1.00	0.99	1.00	0.97	0.99	0.93	0.96	0.89	0.78	0.72
24	1.00	1.00	1.00	0.98	0.99	0.94	0.97	0.89	0.82	0.74

Figure 1 Probability of attaining target ROR(5%)

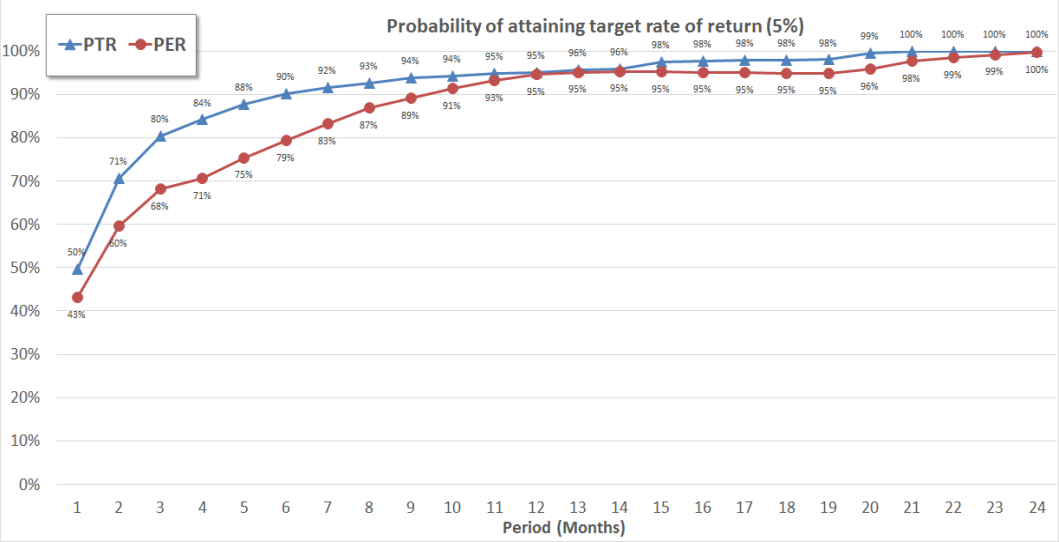


Figure 2 Probability of attaining target ROR(10%)

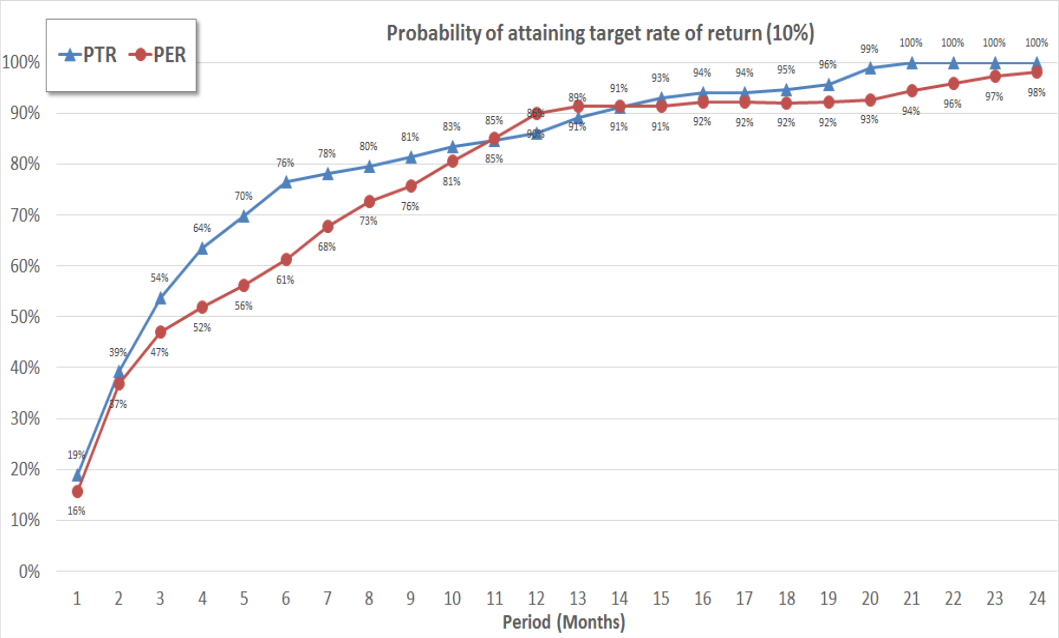


Figure 3 Probability of attaining target ROR(15%)

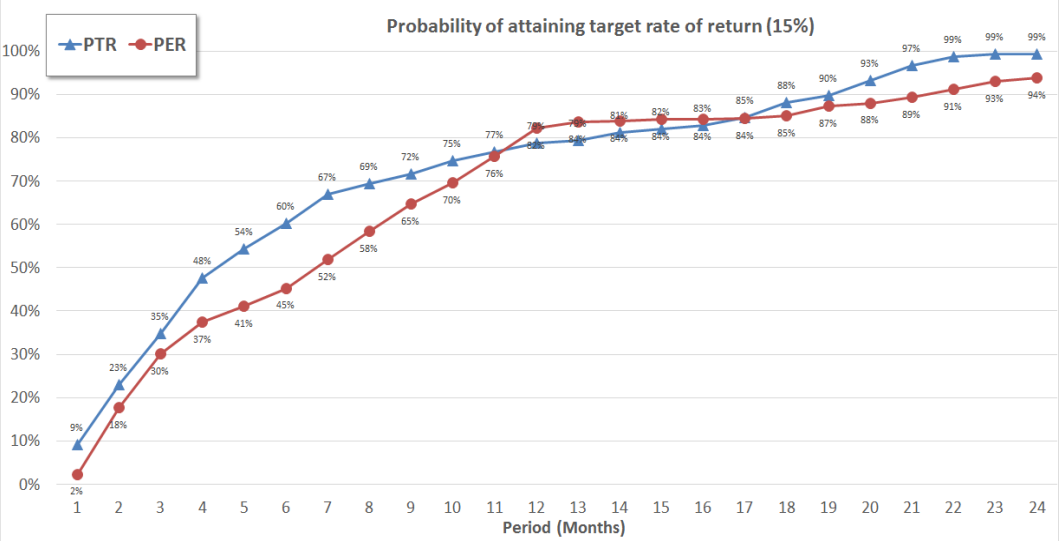


Figure 4 Probability of attaining target ROR(20%)

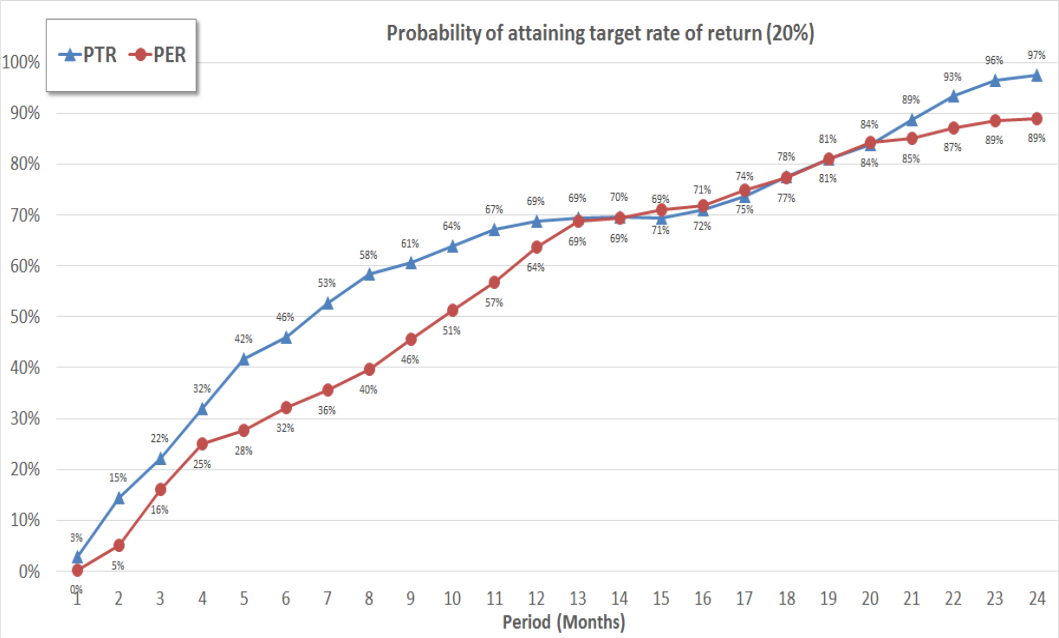
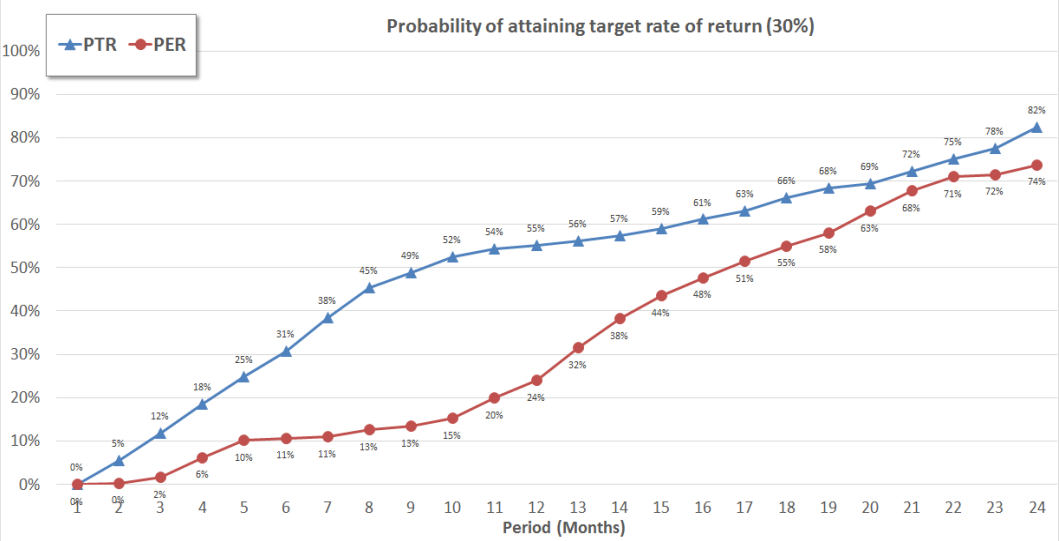


Figure 5 Probability of attaining target ROR(30%)



In Table 2, there are results of simulation when the target ROR is 40%, 50%, 60%, 70% and 80% are included. The results of these simulation are similar to those of 30%. The probability of attaining target goal of PTR portfolios is higher than PTR portfolios in every months. Figure 6, Figure 7, Figure 8, Figure 9 and Figure 10 shows the results of simulation when the target ROR is 40%, 50%, 60%, 70% and 80%.

Table 2 Probability of attaining target ROR (40% to 80%)

Period (Months)	Probability of attaining target ROR (portfolio consisted of bottom 20)									
	40%		50%		60%		70%		80%	
	PTR	PER	PTR	PER	PTR	PER	PTR	PER	PTR	PER
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.05	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00
4	0.09	0.00	0.04	0.00	0.03	0.00	0.01	0.00	0.00	0.00
5	0.16	0.02	0.08	0.00	0.03	0.00	0.02	0.00	0.02	0.00
6	0.20	0.02	0.12	0.00	0.06	0.00	0.03	0.00	0.01	0.00
7	0.27	0.03	0.16	0.00	0.08	0.00	0.05	0.00	0.01	0.00
8	0.33	0.02	0.21	0.00	0.12	0.00	0.07	0.00	0.02	0.00
9	0.39	0.02	0.27	0.00	0.17	0.00	0.12	0.00	0.04	0.00
10	0.41	0.04	0.31	0.01	0.22	0.00	0.17	0.00	0.07	0.00
11	0.46	0.04	0.36	0.01	0.26	0.00	0.19	0.00	0.09	0.00
12	0.48	0.07	0.40	0.02	0.34	0.00	0.26	0.00	0.13	0.00
13	0.51	0.11	0.44	0.05	0.37	0.00	0.30	0.00	0.18	0.00

14	0.55	0.16	0.47	0.07	0.41	0.01	0.32	0.00	0.19	0.00
15	0.56	0.24	0.49	0.09	0.43	0.01	0.36	0.00	0.23	0.00
16	0.59	0.28	0.49	0.14	0.44	0.06	0.36	0.01	0.26	0.00
17	0.59	0.33	0.49	0.18	0.43	0.10	0.36	0.04	0.26	0.01
18	0.60	0.37	0.49	0.23	0.44	0.15	0.37	0.06	0.26	0.01
19	0.61	0.39	0.49	0.25	0.44	0.17	0.37	0.08	0.28	0.03
20	0.62	0.43	0.52	0.27	0.45	0.18	0.39	0.10	0.29	0.03
21	0.64	0.48	0.52	0.30	0.46	0.20	0.41	0.10	0.31	0.03
22	0.66	0.52	0.53	0.35	0.46	0.22	0.42	0.11	0.34	0.04
23	0.68	0.58	0.57	0.41	0.49	0.27	0.42	0.15	0.35	0.05
24	0.70	0.63	0.60	0.46	0.55	0.29	0.47	0.17	0.36	0.06

Figure 6 Probability of attaining target ROR(40%)

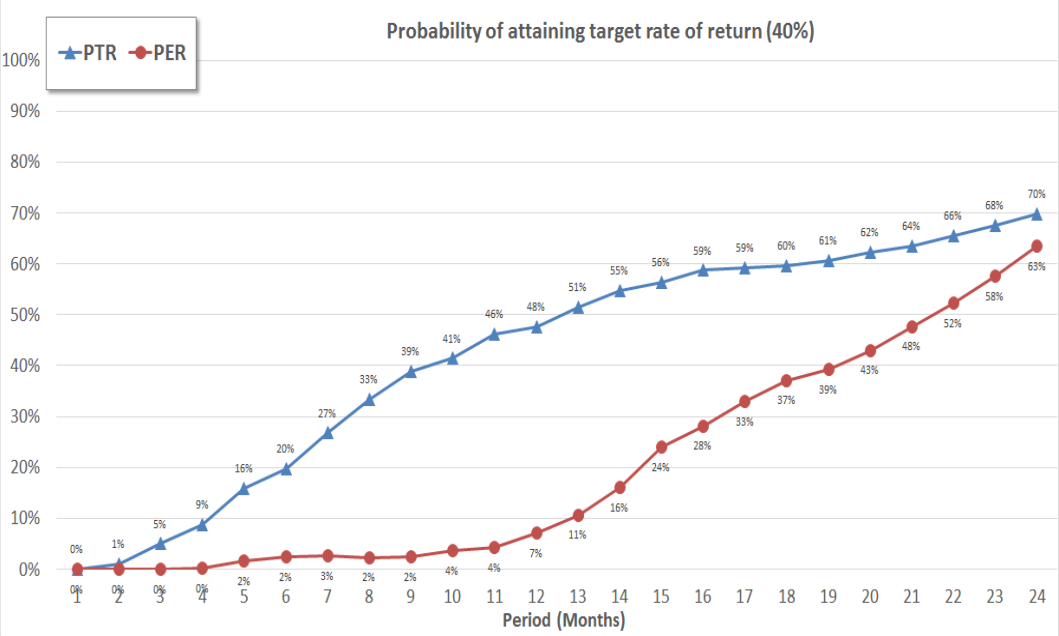


Figure 7 Probability of attaining target ROR(50%)

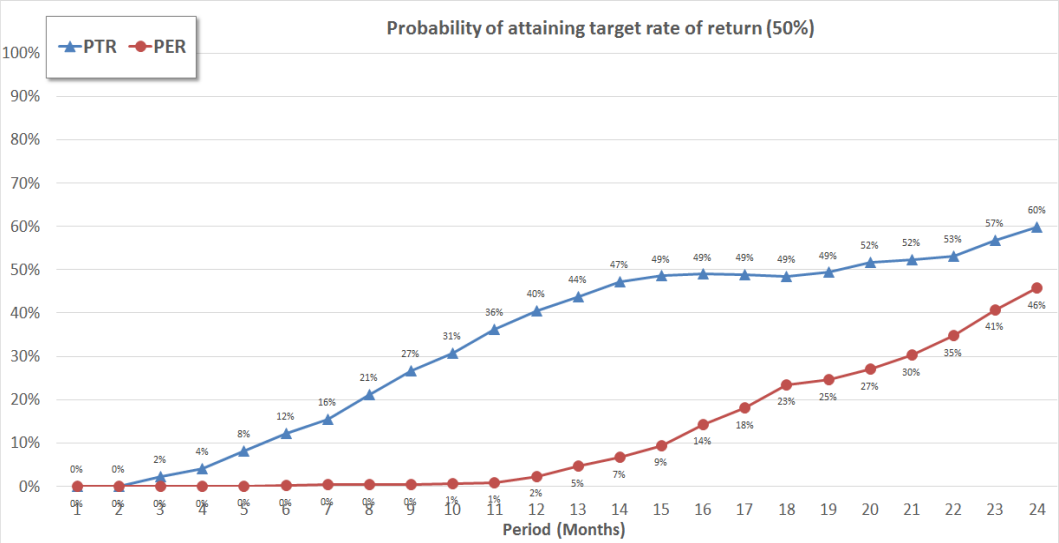


Figure 8 Probability of attaining target ROR(60%)

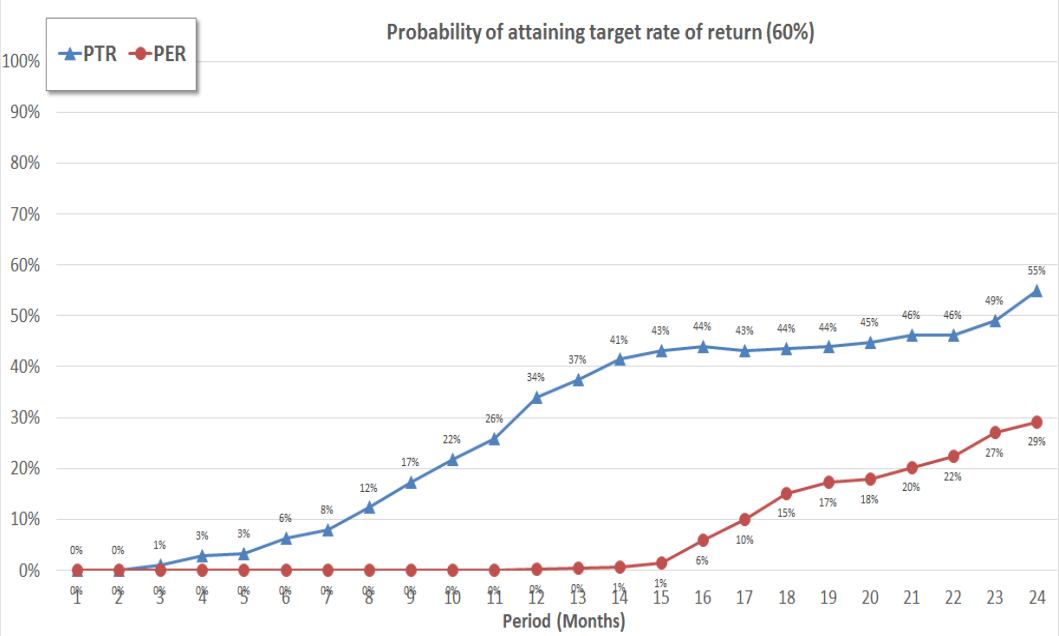


Figure 9 Probability of attaining target ROR(70%)

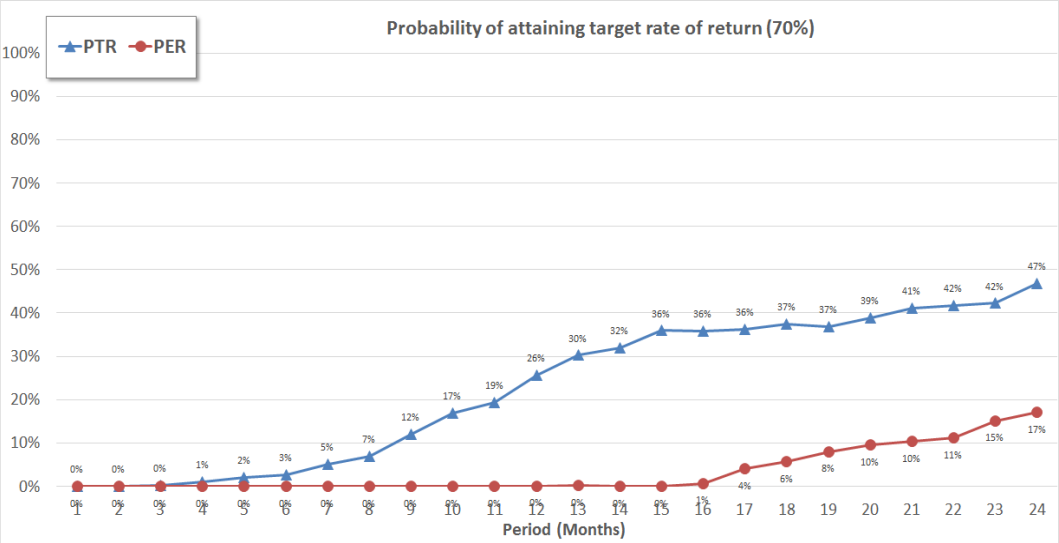
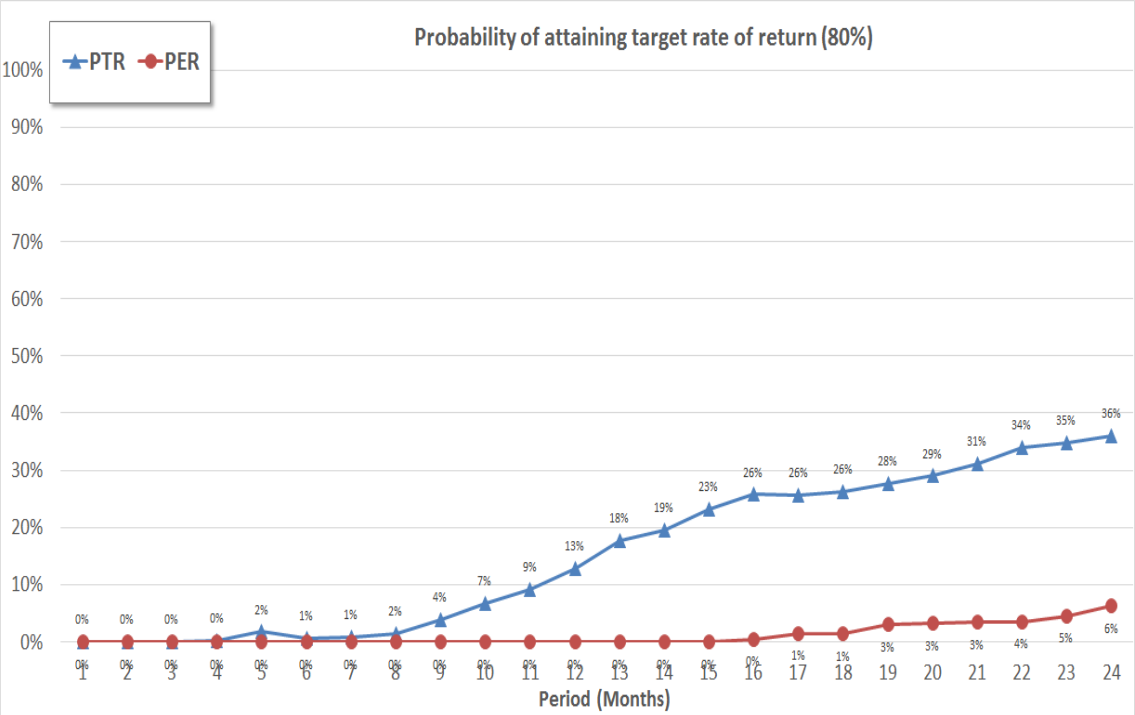


Figure 10 Probability of attaining target ROR(80%)



4.2. Results of simulation of PTR considering size effect

The performance of portfolios are different depend on the firm size. The result of simulation 4.1. mostly stays equal. It means that portfolios consist of low PTR stock items considering firm size meet the target ROR with higher probability than portfolios consist of low PER stock items in the same range. Table 3 shows the probability of attaining target ROR according to the firm size when the target ROR is 20%. The portfolio of range 4, firm size between 50 to 100 billion KRW results most high probability. The simulation results show that the portfolio of firm size between 50 to 100 billion KRW attain the target ROR with high probability when we hold it more than 10 to 12 months. And when we exclude range 1(which do not consider firm size), the range 4(firm size between 50 to 100 billion KRW) attain the goal with highest probability. It is presented in Figures below.

Table 3 Probability of attaining target ROR(20%) considering firm size

Target 20%	Firm size (billion)													
Period (Months)	∞ 0~		∞ 30~		30~50		50~100		100~200		200~400		400~2000	
	PTR	PER	PTR	PER	PTR	PER	PTR	PER	PTR	PER	PTR	PER	PTR	PER
1	0.03	0.00	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2	0.15	0.05	0.08	0.05	0.10	0.05	0.05	0.06	0.07	0.01	0.05	0.02	0.01	0.01
3	0.22	0.16	0.12	0.15	0.16	0.12	0.14	0.16	0.12	0.07	0.09	0.06	0.04	0.02
4	0.32	0.25	0.20	0.22	0.18	0.19	0.27	0.22	0.17	0.15	0.14	0.13	0.07	0.08
5	0.42	0.28	0.31	0.24	0.24	0.25	0.36	0.29	0.21	0.20	0.19	0.20	0.13	0.14
6	0.46	0.32	0.38	0.27	0.30	0.29	0.45	0.34	0.28	0.26	0.24	0.24	0.18	0.18
7	0.53	0.36	0.46	0.29	0.37	0.33	0.51	0.39	0.31	0.30	0.28	0.30	0.26	0.20
8	0.58	0.40	0.51	0.32	0.44	0.41	0.54	0.45	0.33	0.32	0.33	0.33	0.38	0.22
9	0.61	0.46	0.54	0.34	0.51	0.48	0.59	0.49	0.35	0.37	0.35	0.35	0.48	0.23
10	0.64	0.51	0.59	0.35	0.55	0.54	0.63	0.54	0.39	0.44	0.37	0.38	0.55	0.24
11	0.67	0.57	0.64	0.41	0.60	0.62	0.69	0.59	0.43	0.48	0.40	0.38	0.59	0.24
12	0.69	0.64	0.68	0.50	0.68	0.70	0.74	0.61	0.47	0.52	0.41	0.39	0.65	0.26
13	0.69	0.69	0.72	0.58	0.74	0.75	0.79	0.66	0.55	0.57	0.46	0.42	0.70	0.28
14	0.70	0.69	0.75	0.62	0.79	0.76	0.82	0.67	0.60	0.63	0.51	0.44	0.76	0.29
15	0.69	0.71	0.76	0.63	0.83	0.76	0.85	0.69	0.62	0.68	0.55	0.50	0.80	0.31
16	0.71	0.72	0.76	0.64	0.86	0.77	0.91	0.70	0.63	0.72	0.60	0.54	0.82	0.34
17	0.74	0.75	0.78	0.68	0.88	0.78	0.94	0.71	0.65	0.74	0.64	0.61	0.83	0.34
18	0.78	0.77	0.80	0.73	0.90	0.79	0.96	0.73	0.68	0.74	0.68	0.64	0.85	0.33
19	0.81	0.81	0.81	0.76	0.92	0.78	0.97	0.77	0.70	0.75	0.70	0.68	0.86	0.33
20	0.84	0.84	0.81	0.81	0.92	0.79	0.98	0.79	0.72	0.75	0.72	0.73	0.86	0.34
21	0.89	0.85	0.83	0.85	0.93	0.82	0.98	0.80	0.75	0.75	0.75	0.76	0.86	0.37
22	0.93	0.87	0.83	0.89	0.96	0.87	0.98	0.82	0.82	0.77	0.78	0.79	0.89	0.39
23	0.96	0.89	0.84	0.90	0.97	0.92	0.99	0.87	0.87	0.79	0.82	0.81	0.90	0.42
24	0.97	0.89	0.83	0.90	0.98	0.94	0.99	0.89	0.89	0.80	0.84	0.84	0.91	0.45

Figure 11 Probability of attaining target ROR(20%), PTR(size effect)

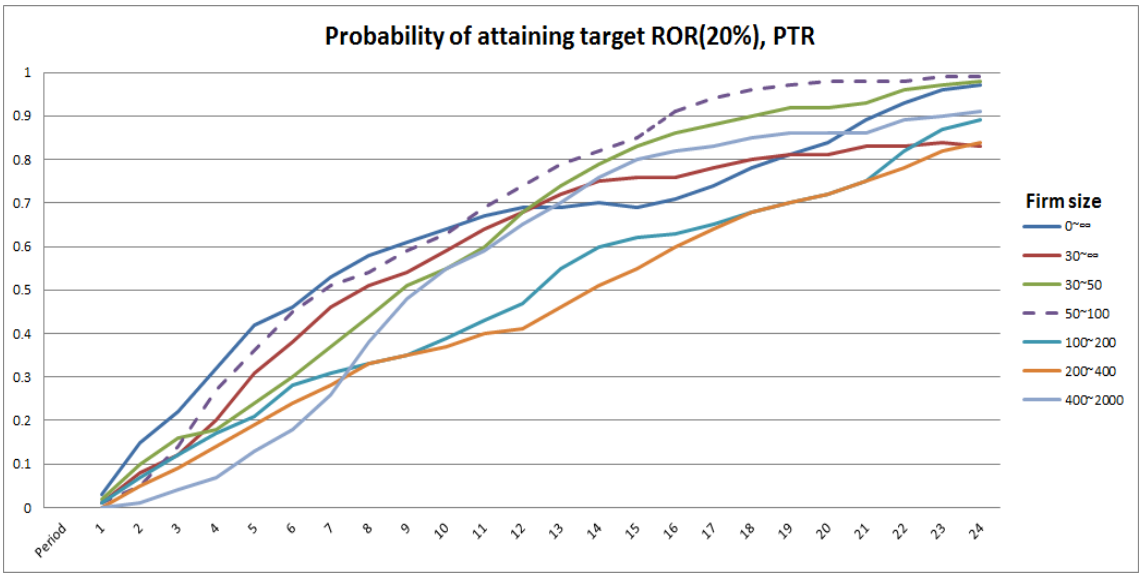


Table 4 Probability of attaining target ROR(30%) considering firm size

Target 30%	Firm size (billion)													
Period (Months)	∞ 0~		∞ 30~		30~50		50~100		100~200		200~400		400~2000	
	PTR	PER	PTR	PER	PTR	PER	PTR	PER	PTR	PER	PTR	PER	PTR	PER
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.05	0.00	0.00	0.00	0.03	0.02	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
3	0.12	0.02	0.06	0.01	0.11	0.05	0.04	0.02	0.05	0.00	0.03	0.00	0.00	0.00
4	0.18	0.06	0.07	0.06	0.13	0.09	0.07	0.06	0.06	0.00	0.06	0.01	0.01	0.00
5	0.25	0.10	0.11	0.11	0.13	0.11	0.12	0.08	0.07	0.03	0.06	0.02	0.02	0.01
6	0.31	0.11	0.18	0.11	0.15	0.13	0.19	0.12	0.07	0.04	0.08	0.03	0.02	0.02
7	0.38	0.11	0.25	0.10	0.21	0.14	0.28	0.14	0.10	0.05	0.10	0.03	0.03	0.06
8	0.45	0.13	0.33	0.10	0.24	0.17	0.34	0.17	0.12	0.06	0.15	0.12	0.07	0.10
9	0.49	0.13	0.38	0.10	0.27	0.19	0.40	0.20	0.14	0.08	0.18	0.18	0.10	0.13
10	0.52	0.15	0.41	0.10	0.29	0.22	0.44	0.23	0.17	0.10	0.21	0.23	0.17	0.15

11	0.54	0.20	0.45	0.10	0.32	0.28	0.48	0.26	0.18	0.14	0.23	0.26	0.21	0.15
12	0.55	0.24	0.46	0.13	0.35	0.33	0.53	0.34	0.19	0.19	0.28	0.27	0.28	0.16
13	0.56	0.32	0.52	0.20	0.42	0.41	0.61	0.39	0.22	0.24	0.32	0.30	0.32	0.16
14	0.57	0.38	0.56	0.27	0.47	0.52	0.69	0.43	0.29	0.29	0.37	0.31	0.34	0.18
15	0.59	0.44	0.58	0.33	0.53	0.56	0.73	0.45	0.33	0.38	0.40	0.33	0.36	0.20
16	0.61	0.48	0.58	0.37	0.59	0.58	0.75	0.47	0.36	0.44	0.44	0.36	0.39	0.24
17	0.63	0.51	0.59	0.38	0.65	0.63	0.79	0.49	0.40	0.49	0.47	0.39	0.44	0.25
18	0.66	0.55	0.61	0.40	0.68	0.66	0.84	0.52	0.44	0.52	0.52	0.44	0.46	0.26
19	0.68	0.58	0.65	0.45	0.73	0.70	0.86	0.52	0.47	0.53	0.56	0.48	0.48	0.26
20	0.69	0.63	0.67	0.52	0.75	0.72	0.88	0.53	0.49	0.55	0.61	0.50	0.50	0.27
21	0.72	0.68	0.70	0.57	0.75	0.73	0.92	0.56	0.55	0.54	0.63	0.54	0.53	0.28
22	0.75	0.71	0.75	0.61	0.78	0.77	0.92	0.57	0.58	0.54	0.66	0.57	0.55	0.29
23	0.78	0.72	0.75	0.65	0.84	0.80	0.94	0.59	0.64	0.55	0.68	0.62	0.56	0.31
24	0.82	0.74	0.76	0.71	0.86	0.83	0.95	0.61	0.70	0.56	0.74	0.64	0.56	0.34

Figure 12 Probability of attaining target ROR(30%), PTR(size effect)

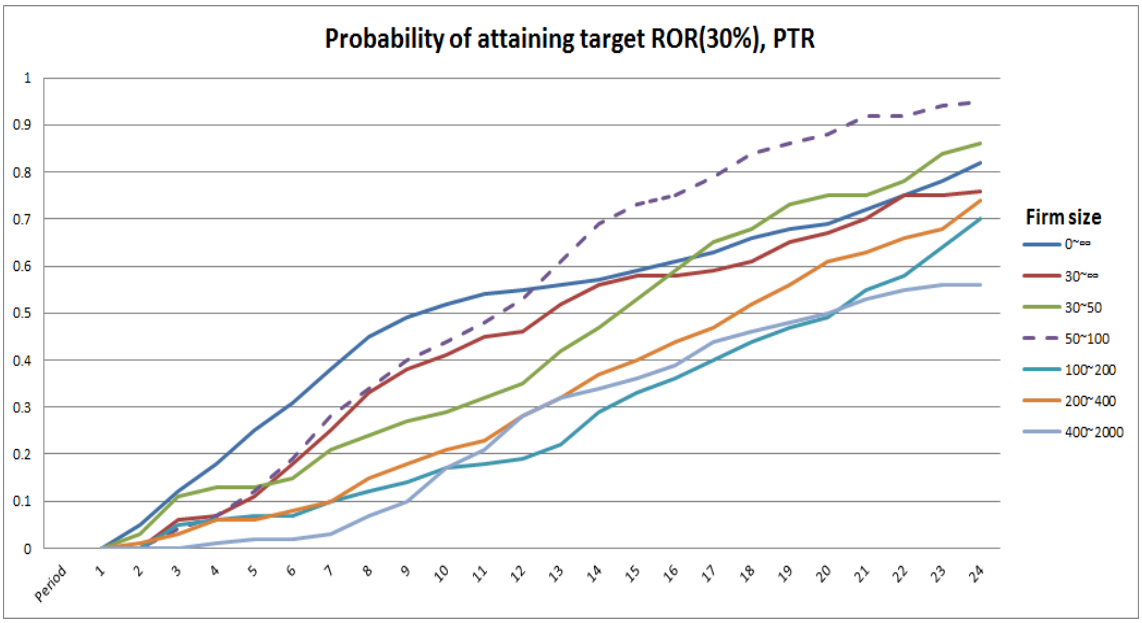
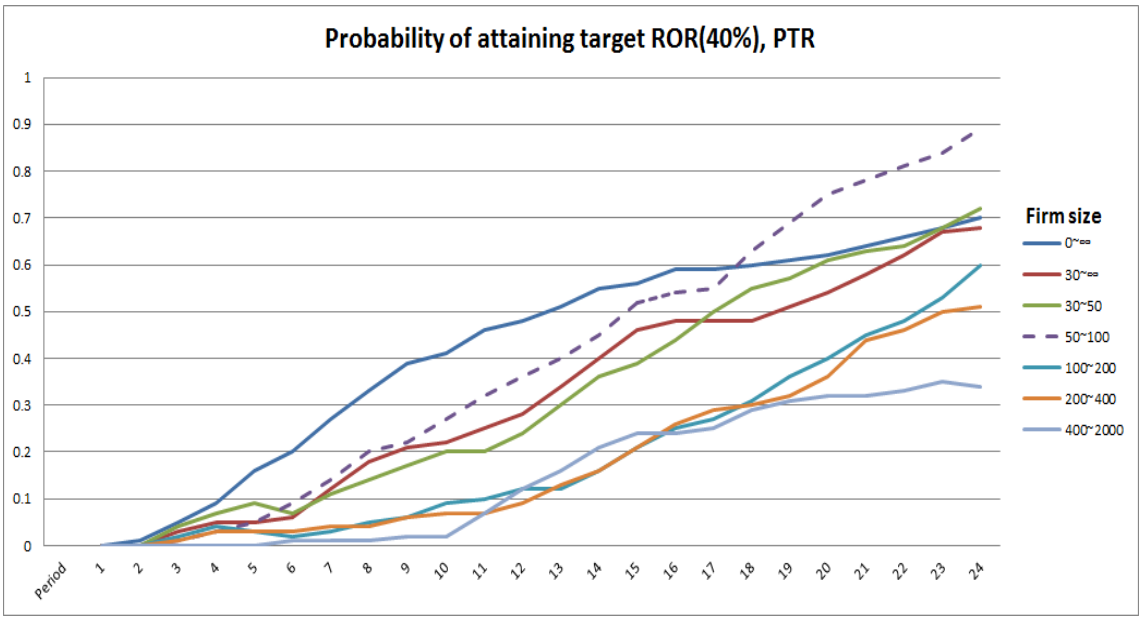


Table 5 Probability of attaining target ROR(40%) considering firm size

Target 40%	Firm size (billion)													
Period (Months)	∞ 0~		∞ 30~		30~50		50~100		100~200		200~400		400~2000	
	PTR	PER	PTR	PER	PTR	PER	PTR	PER	PTR	PER	PTR	PER	PTR	PER
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.05	0.00	0.03	0.00	0.04	0.01	0.01	0.00	0.02	0.00	0.01	0.00	0.00	0.00
4	0.09	0.00	0.05	0.00	0.07	0.03	0.03	0.01	0.04	0.00	0.03	0.00	0.00	0.00
5	0.16	0.02	0.05	0.01	0.09	0.04	0.05	0.02	0.03	0.00	0.03	0.00	0.00	0.00
6	0.20	0.02	0.06	0.02	0.07	0.07	0.09	0.03	0.02	0.00	0.03	0.00	0.01	0.00
7	0.27	0.03	0.12	0.02	0.11	0.09	0.14	0.04	0.03	0.00	0.04	0.00	0.01	0.00
8	0.33	0.02	0.18	0.02	0.14	0.09	0.20	0.04	0.05	0.01	0.04	0.02	0.01	0.01
9	0.39	0.02	0.21	0.01	0.17	0.09	0.22	0.06	0.06	0.03	0.06	0.06	0.02	0.03
10	0.41	0.04	0.22	0.01	0.20	0.09	0.27	0.08	0.09	0.04	0.07	0.08	0.02	0.05
11	0.46	0.04	0.25	0.02	0.20	0.12	0.32	0.10	0.10	0.06	0.07	0.09	0.07	0.07
12	0.48	0.07	0.28	0.03	0.24	0.17	0.36	0.14	0.12	0.07	0.09	0.10	0.12	0.10
13	0.51	0.11	0.34	0.07	0.30	0.19	0.40	0.18	0.12	0.08	0.13	0.11	0.16	0.11
14	0.55	0.16	0.40	0.10	0.36	0.26	0.45	0.22	0.16	0.10	0.16	0.13	0.21	0.11
15	0.56	0.24	0.46	0.15	0.39	0.39	0.52	0.24	0.21	0.14	0.21	0.15	0.24	0.11
16	0.59	0.28	0.48	0.16	0.44	0.45	0.54	0.27	0.25	0.18	0.26	0.16	0.24	0.12
17	0.59	0.33	0.48	0.18	0.50	0.51	0.55	0.31	0.27	0.20	0.29	0.20	0.25	0.14
18	0.60	0.37	0.48	0.20	0.55	0.55	0.63	0.36	0.31	0.22	0.30	0.23	0.29	0.16
19	0.61	0.39	0.51	0.22	0.57	0.60	0.69	0.39	0.36	0.24	0.32	0.25	0.31	0.17
20	0.62	0.43	0.54	0.25	0.61	0.63	0.75	0.42	0.40	0.27	0.36	0.27	0.32	0.18
21	0.64	0.48	0.58	0.31	0.63	0.65	0.78	0.44	0.45	0.29	0.44	0.29	0.32	0.18
22	0.66	0.52	0.62	0.34	0.64	0.68	0.81	0.46	0.48	0.28	0.46	0.31	0.33	0.19
23	0.68	0.58	0.67	0.39	0.68	0.72	0.84	0.48	0.53	0.27	0.50	0.32	0.35	0.19
24	0.70	0.63	0.68	0.47	0.72	0.74	0.89	0.50	0.60	0.27	0.51	0.35	0.34	0.20

Figure 13 Probability of attaining target ROR(40%), PTR(size effect)



Rolf W. Banz showed that on average, the common stock of small firms had higher returns than common stock of large firms. (the size effect) In this study, the results of long term investment show firm size between 50 to 100 billion attained target ROR with highest probability. But in short term investment, portfolios with no constraint show highest probability of attaining target ROR.

4.3. Comparing invest performance of PTR and KOSPI

Additionally, we analyzed results of actual investment of portfolios consisting of low PTR stock items. This investment is conducted by Wizdomain. The maximum investment period is 3 months. If the portfolio attaining the target ROR(5%) during this period, Wizdomain sell the portfolio. And if the portfolio do not attaining the target ROR during 3 months, they sell it at the end of this period. This actual investment started September 2015. So far the ROR of low PTR portfolio is higher than KOSPI and KOSDAQ bench mark. The result is shown in Table 6.

Table 6 Results of actual investment

Portfolio	Start	Sold	Investment Period(days)	ROR (%)	KOSPI BM(%)	KOSDAQ BM(%)
A	2015-09-01	2015-11-08	68	10.96	6.63	3.16
B	2015-11-09		25	2.35	3.14	1.91
C	2015-09-02	2015-12-04	93	4.00	3.09	1.14
D	2015-09-07	2015-12-04	88	4.00	2.22	3.45
E	2015-09-14	2015-12-04	81	4.55	0.49	-0.45
F	2015-09-21	2015-12-04	74	4.55	1.62	0.45

G	2015-12-04		-	0.00		
H	2015-12-04		-	0.00		
I	2015-12-04		-	-0.23		
J	2015-09-25		69	-1.53	1.62	0.45
K	2015-09-30	2015-10-20	20	4.50	3.90	1.88
L	2015-10-20		44	3.10	0.59	1.07
M	2015-10-05		59	-0.46	-0.19	-0.78
N	2015-10-30	2015-12-02	32	4.48	-1.74	-0.66

5. Conclusion

In this paper an attempt was made to determine the relationship between PTR and investment performance of portfolios by simulation. The low PER portfolios and low PTR portfolios both attained the target ROR in high probability. During the period January 2010−July 2015, the low PTR portfolios seem to have, on average, attained target ROR in higher probability than the low PER portfolios. These results suggest that PTR can be used to consist a portfolio as an indicator of future investment performance.

The evidence presented in this study suggests that the size effect exists in portfolios consist of low PTR stock items. This size effect is different from R. W. Banz(1981). He finds that the common stock of small firms had, on average, higher risk adjusted returns. But in this study, we found that portfolios consisted of stocks from market value between 50 to 100 billion KRW mostly resulted higher rate of return than others. And concluded there is a size effect in PTR portfolios.

We suggest one another indicator PTR, which evaluates the firm's technology value. The technology value includes firm's patented R&D output and patents the firm possessed by purchase. Accordingly, low PTR means that the value of firm's R&D activity is not fully reflected in security prices and investing portfolios with low PTR stocks will result in high investment performance. In the simulation of long term investment, there was a size effect. But we do not find out clear explanation for this result. Further research should consider the relationship between size and other related factors.

The findings of this study confirmed the PTR portfolios outperform the PER portfolios. Therefore managers should consider PTR and technology value when they make investment decisions. Especially, firms between market value of 50 to 100 billion KRW should consider PTR. Due to the size effect, considering technology value is more proper for those firms.

Limitation of this research is there can be unknown factors correlate with patent value. In addition to this, we only considered the probability of getting target return and did not consider the

probability of loss. By analyzing actual investment results, we included both probability of win and loss. However, this investment is started from September 2015. Afterwards additional investment analysis is needed. And there is no theoretical foundation for size effect. We do not know why is firm size of that range showed highest return. Further research should consider the size and other patent value related factors.

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국문 초록

PTR 에 따른 주식의 투자성과 연구

-KOSPI 와 KOSDAQ 상장주 투자 시뮬레이션

전가영

경영학과 생산관리 전공

서울대학교 대학원

기업의 연구 개발이 투자활동에 해당한다는 것은 널리 받아들여지고 있다. 이 투자활동의 결과물은 기업의 시장가치에 반영되어야한다. Bosworth, D 와 Rogers, M 은 연구개발과 특허 활동이 기업의 시장가치와 유의적인 양의 관계가 있다는 것을 그들의 연구에서 보였다. 또한, K-C, Chang et al.(2012)은 기업이 보유한 특허의 수와 기업 성과의 관계에 대한 연구에서 특허가 널리 이용되고 있다는 것을 보였다.

특허 성과와 기업 성과의 관계에 관한 연구에서는 많은 학자들이 특허 인용 지수와 기업의 시장가치 간에 양의 관계가 있다는 것을 확인했다.

본 논문에서는 기업의 기술 가치를 평가하는 새로운 지표인 PTR 을 제시한다. 여기에서 기술 가치는 기업 연구개발 활동의 결과물인 특허와 기업이 매수를 통해 보유하고 있는 특허를 모두 포함한다. 따라서 PTR 이 낮다는 것은 기업의 연구개발 활동이 주가에 완전히 반영되지 않았다는 것을 의미하고, PTR 이 낮은 주식으로 이루어진 포트폴리오에 투자하여 높은 투자 성과를 얻을 수 있었다. 시뮬레이션 결과에 따르면 장기 투자의 경우에는 규모 효과가 있었다.

본 논문의 시뮬레이션 결과, PTR 과 높은 상관관계가 있는 주식 그룹에서 PTR 이 낮은 주식으로 구성된 포트폴리오가 PER 이 낮은 주식으로 구성된 포트폴리오보다 더 높은 성과를 보였다. 그러므로 경영자들은 투자의사결정을 할 때 PTR 과 기술 가치를 고려한다면 보다 높은 투자 성과를 얻을 수 있을 것이다. 특히 기업 시장 가치가 500 억 원에서 1000 억 원 사이에 해당하는 기업에 투자할 때에는 PTR 을 고려해야 한다. 시뮬레이션 결과, 규모 효과 때문에 이 범위에 해당하는 기업의 경우 기술 가치를 고려하는 것이 더 적절하였다.

주요어 : 특허 가치; 특허-기술 비율; 연구개발 성과지표; 특허 가치 지표

학번 : 2014-20441

경영학석사학위논문

Investment performance of Common stocks in relation to their PTR

-For KOSPI and KOSDAQ common stocks, simulated stock investment

PTR 에 따른 주식의 투자성과 연구

-KOSPI 와 KOSDAQ 상장주 투자 시뮬레이션

2016 년 2 월

서울대학교 대학원

경영학과 생산관리전공

전 가 영

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지도교수 오 정 석

이 논문을 경영학 석사학위논문으로 제출함

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전 가 영

전가영의 석사학위논문을 인준함

2016 년 2 월

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Abstract

It is widely understood that the Research and development (R&D) is an investment activity. And the output is an intangible asset that should be reflected in the observed market value of the firm. Bosworth, D. and Rogers, M suggested in their work that R&D and patent activity are positively and significantly associated with market value. Also, K.-C. Chang et al. (2012) showed patents are widely adopted in research concerning relationship between patent counts and corporation performance.

In research regarding the relationship between patent performance and corporation performances, many scholars have confirmed the positive relation between patent citations and market value of firm. We suggest one another indicator PTR, which evaluates the firm's technology value. The technology value includes firm's patented R&D output and patents the firm possessed by purchase. Accordingly, low PTR means that the

value of firm's R&D activity is not fully reflected in security prices and investing portfolios with low PTR stocks will result in high investment performance. In the simulation of long term investment, there was a size effect.

The findings of this study confirmed the PTR portfolios outperform the PER portfolios. Therefore managers should consider PTR and technology value when they make investment decisions. Especially, firms between market value of 50 to 100 billion KRW should consider PTR. Due to the size effect, considering technology value is more proper for those firms.

Key words : patent value; patent-technology ratio; research and development output indicator; patent value indicator.

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1. Introduction

It is widely understood that the Research and development (R&D) is an investment activity, the output of which is an intangible asset that can be labeled as the firm's "knowledge stock".(Hall, B. H., Jaff, A. and Trajtenberg, M., 2005). K.-C. Chang et al. (2012) showed patents, serve as an important output indicator of research and development activities, are widely adopted in researches concerning relationship between patent counts and corporation performance. Schankerman, M. and Pakes, A. (1986) empirically tested the value of the benefits derived from the patent.

And they demonstrated that the distribution of patent rights' private value is sharply skewed. Hall, Jaffe, and Trajtenberg provided evidence that the intensity of citations of companies' patents is also associated with their market values. In research regarding the relationship between patent performance and corporation performances, many scholars have confirmed the positive relation between patent citations and market value of firm.

Deng et al. (1999) empirical study confirmed that the higher patent counts and patent citations are, the better corporation performance (stock return, market-to-book ratio) is. Besides, findings of Harhoff, Narin, Scherer, and Vopel (1999), and Harhoff, Scherer, and Vopeld (2003) also suggested positive relation between patent value and patent citations.

We suggest PTR as an indicator to measure the patent value. PTR is defined as market value divided by technology value. The technology value means the integration of patented R&D output and patents the firm possessed by purchase. Thus, PTR is an indicator which can be used to evaluate whether the firm's technology value is properly reflected in the market value.

Low PTR means those technology value of company is underestimated. Therefore, by investing the portfolio consisted of low PTR stock items will result high returns. S. Basu (1977) empirically showed low PER portfolios did earn superior returns. The result of this study show that the PTR portfolios outperform the PER portfolios.

The remainder of this paper is organized as follows. In section 2, the literature related to this study is reviewed. Section 3 describes the research methodology. Section 4 presents the results of simulation and actual investment. The paper concludes with Section 5.

2. Literature review

Research and Development (R&D) conducted by private firms is an investment activity. The output of R&D is an intangible asset which can be called the firm's "Knowledge stock". Because this activity contributes positively to the firm's future net cash flows, the value of this knowledge stock should be reflected in the observed market value of the firm (Hall, B. H., Jaffe, A. and Trajtenberg, M., 2005).

There are several studies that explain the role of patents as an output indicator of R&D activities. Brosworth, D. and Rogers, M. considered the value of innovation to large Australian firms. Specifically, they investigated how R&D and intellectual property activity influences the market value of firms, using a Tobin's q approach. The findings suggested that R&D and patent activity are positively and significantly associated with market value. F.M. Scherer showed that an inventive output is positively correlated with the growth of corporate profits in 448 firms appearing on Fortune's list of 500 largest U.S. industrial corporations in 1955.

These studies show the positive relationship between patent counts and firm performance.

However, patent counts is not sufficient to offer information regarding innovation output because of difference in patent's value. Some enterprises may have only a small number of patents but with high influence, while others may have many patents yet low in influence. This phenomenon is also known as the skewed distribution of patent value which means that patents with high value and high influence only take a small portion of total patents.(K-C, Chang et al., 2012) Therefore, simple patent count cannot be seen as a suitable measure of innovation activity (R&D).

The following studies attempted to resolve the value-heterogeneity problem in measuring patent stock. Schankerman, M. and Pakes, A. (1986) empirically tested the value of the benefits derived from the patent. And demonstrated that the distribution of the private value of patent rights is sharply skewed in the United Kingdom, France and Germany. There are a lot of patent rights with low economic value, but the tail of the distribution contains highly valuable patent rights.

Many scholars suggest that the patent citations could be used to measure the influence of patent. The idea of measuring patent citations is based on the same way in Bibliometrics that the influence of certain publication could be measured by its citation. So that patent citations could also be used to measure the quality and the influence of patents. By conducting patent citation analysis, fundamental or important patents can be identified (K.-C. Chang et al., 2012).

In studies regarding the relationship between patent performance and corporation performances, many scholars have confirmed the positive relation between patent citations and market value. At the same time, patent citations is also highly interrelated with profits and sales. Deng et al. (1999) empirically confirmed that the higher patent counts and patent citations are, the better corporation performance(stock return, market-to-book ratio) is. Also, Harhoff, Narin, Scherer, and Vopel (1999) and Harhoff, Schererec, and Vopeld (2003) suggest positive relation between patent value and patent citations. Therefore, we can draw

the conclusion that high patent citations also reflects high economic value.

Chen and Chang studied the relationship between corporate market value and four patent quality indicators – relative patent position (RPP), revealed technology advantage (RTA), Herfindahl–Hirschman Index of patents (HHI of patents), and patent citations – in US pharmaceutical industry. The results showed that patent citations were positively associated with corporate market value. Using patent citation and other patent quality indicators to measure the influence of patent can be useful, but we suggest PTR (Price to Technology Ratio) as a new indicator to measure the influence of patent. We can suggest it by comparing the investment performance based on PTR and KOSPI (Korea Composite Stock Price Index).

PTR is defined as market value divided by technology value. In PTR, the technology value means the integration of patented R&D output and patents the firm possessed by purchase. PTR is an indicator of the future investment performance of a security. The numerator of PTR was defined as the market value of common

stock and the denominator as technology value. The technology value means the value of technology which is patented and Wizdomain used global patent price to measure the paten value.

$$PTR = \frac{\text{Aggregate Market Value}}{\Sigma \text{ Price of Patent}} = \frac{\text{Share Price}}{\text{TPS}}$$

*TPS: Technology-value Per Share

This is similar to PER(price-to-earnings ratio), or P/E ratio, an equity valuation multiple.

S. Basu (1977) empirically showed the investment performance of common stocks is related to their PER. Due to exaggerated investor expectations, PER can be an indicators of future investment performance. Portfolios consisted of low price-to-earnings ratios did earn superior returns. Low PER means the stock price is underestimated and indicates future investment performance higher than market average. In a similar way, we can suggest low PTR can get high investment performance. And by comparing the investment performance of portfolios consisted of

PER and PTR, we can show the role of PTR is an superior indicator of future investment performance than PER.

H1. PTR portfolios outperform than PER portfolios.

Rolf W. BANZ (1981) found that smaller firms have had higher risk adjusted returns, on average, than larger firms. It is called "size effect" and has been in existence for at least forty years. The size effect is not linear in the market value, the main effect occurs for very small firms. We suggest this size effect will also appear when we apply PTR.

H2. The PTR portfolio investment performance has a size effect.

3. Data and Methodology

The following research design was employed to examine the relationship between PTR and investment performance of securities. For any given period under consideration, portfolios consisting of securities with similar PTR are formed. We conduct a simulation of investment with these portfolios and the performance of portfolios is evaluated in terms of pre-specified measures.

As a test of high investment performance, we compared performance of low PTR portfolio to KOSPI and KOSDAQ bench mark (stocks with high correlation between PTR and ROR) in the same period. Wizdomain consisted a portfolio with low PTR securities and actually traded on Korea stock exchange. The data base and methodological details are now discussed.

3.1. Data base and sample selection criteria

The primary data for this study is drawn from WISEfn, which is a financial information provider, that includes stock price and PER of the Korea stock exchange between January 2010−August 2015. (700 stocks with high correlation between PTR and ROR) The value of patent can be measured in various ways but we used a statistical income approach method which is suggested by Wizdomain.

The portfolio is consisted of 20 stock items which meet the conditions. We invested same amount of money to each stock items consisting portfolios. And we made an assumption that the stock price is not affected by the trade of portfolios. Also we suppose buying and selling is conducted in adjusted closing price and there is no transaction fee.

3.2. Method of Analysis

Beginning with January 2010, the PTR of every sample stock was computed. These ratios were ranked and 20 stock items(firms) from the lower part were selected. Portfolios of PER is also consisted as same as PTR portfolios. And then we conducted a simulation of investment.

After consisting portfolios, we invested same amount to each stock items consisting portfolios. We consisted portfolios everyday(when the information of stock price is exists) from January 2010 to July 2015, we consisted 1372 portfolios. We measured the investment performance(rate of return) of period reflecting market fluctuation of each stock item of portfolios.

$$\text{Rate of Return} = \frac{\text{Aggregate Market Value}}{\text{Investment}}$$

The rate of return of portfolio and the probability of attaining target rate of return is computed monthly.

$$\text{The probability of attaining target ROR} = \frac{\text{Number of portfolios (meet the target)}}{\text{Total Number of the portfolios}}$$

And comparing the investment performance of portfolios consisted of PER and PTR.

Most of the portfolio selection procedures to consider the size effect are identical to the one described above. But the population is divided by the total market value. After forming portfolios to consider firm size, we conducted identical simulation to the one described above.

Finally, we analyzed actual investment of Wizdomain and compared the investment performance to KOSPI and KOSDAQ bench mark. Because the simulation comparing low PER and low PTR portfolios only considered upper side of investment, we considered both gain and loss by analyzing real investment. The portfolio was consisted with low PTR securities and actually traded on Korea stock exchange.

4. Results

4.1. Results of simulation comparing PER and PTR

Tables and figures below show the performance of portfolios consisted of bottom 20 PER and PTR stock items, as the target rate of return changes.

When the target rate of return(ROR) is 5%, the probability of attaining target ROR of PTR portfolio is higher than PER portfolio during the periods(from 1 to 24 months). To see this more clearly, a graph of probability of attaining target ROR appears in Figure 1.

When the target ROR is 10% and 15%, the probability of attaining target rate of return of PTR is superior in most of periods, Table 1 and Figure 2 shows the results of simulation when the target ROR is 10%. And Table 1 and Figure 3 shows the result of 15%. Also, there are results of simulation when the target ROR is 20% and 30%. The result shown in Table 1 and Figure 4, when the target ROR is 20% the result is similar to those

of 10% and 15%. But, the probability of attaining target ROR of PER is higher than PTR portfolios around 12 months. Further research is needed to explain this result.

However the results of 30% target ROR is different. The probability of attaining target goal of PTR portfolios is higher than PTR portfolios in every months. This is shown in Table 1 and Figure 5.

Table 1 Probability of attaining target ROR (5% to 30%)

Period (Months)	Probability of attaining target ROR (portfolio consisted of bottom 20)									
	5%		10%		15%		20%		30%	
	PTR	PER	PTR	PER	PTR	PER	PTR	PER	PTR	PER
1	0.50	0.43	0.19	0.16	0.09	0.02	0.03	0.00	0.00	0.00
2	0.71	0.60	0.39	0.37	0.23	0.18	0.15	0.05	0.05	0.00
3	0.80	0.68	0.54	0.47	0.35	0.30	0.22	0.16	0.12	0.02
4	0.84	0.71	0.64	0.52	0.48	0.37	0.32	0.25	0.18	0.06
5	0.88	0.75	0.70	0.56	0.54	0.41	0.42	0.28	0.25	0.10
6	0.90	0.79	0.76	0.61	0.60	0.45	0.46	0.32	0.31	0.11
7	0.92	0.83	0.78	0.68	0.67	0.52	0.53	0.36	0.38	0.11
8	0.93	0.87	0.80	0.73	0.69	0.58	0.58	0.40	0.45	0.13
9	0.94	0.89	0.81	0.76	0.72	0.65	0.61	0.46	0.49	0.13
10	0.94	0.91	0.83	0.81	0.75	0.70	0.64	0.51	0.52	0.15
11	0.95	0.93	0.85	0.85	0.77	0.76	0.67	0.57	0.54	0.20
12	0.95	0.95	0.86	0.90	0.79	0.82	0.69	0.64	0.55	0.24
13	0.96	0.95	0.89	0.91	0.79	0.84	0.69	0.69	0.56	0.32
14	0.96	0.95	0.91	0.91	0.81	0.84	0.70	0.69	0.57	0.38

15	0.98	0.95	0.93	0.91	0.82	0.84	0.69	0.71	0.59	0.44
16	0.98	0.95	0.94	0.92	0.83	0.84	0.71	0.72	0.61	0.48
17	0.98	0.95	0.94	0.92	0.85	0.84	0.74	0.75	0.63	0.51
18	0.98	0.95	0.95	0.92	0.88	0.85	0.78	0.77	0.66	0.55
19	0.98	0.95	0.96	0.92	0.90	0.87	0.81	0.81	0.68	0.58
20	0.99	0.96	0.99	0.93	0.93	0.88	0.84	0.84	0.69	0.63
21	1.00	0.98	1.00	0.94	0.97	0.89	0.89	0.85	0.72	0.68
22	1.00	0.99	1.00	0.96	0.99	0.91	0.93	0.87	0.75	0.71
23	1.00	0.99	1.00	0.97	0.99	0.93	0.96	0.89	0.78	0.72
24	1.00	1.00	1.00	0.98	0.99	0.94	0.97	0.89	0.82	0.74

Figure 1 Probability of attaining target ROR(5%)

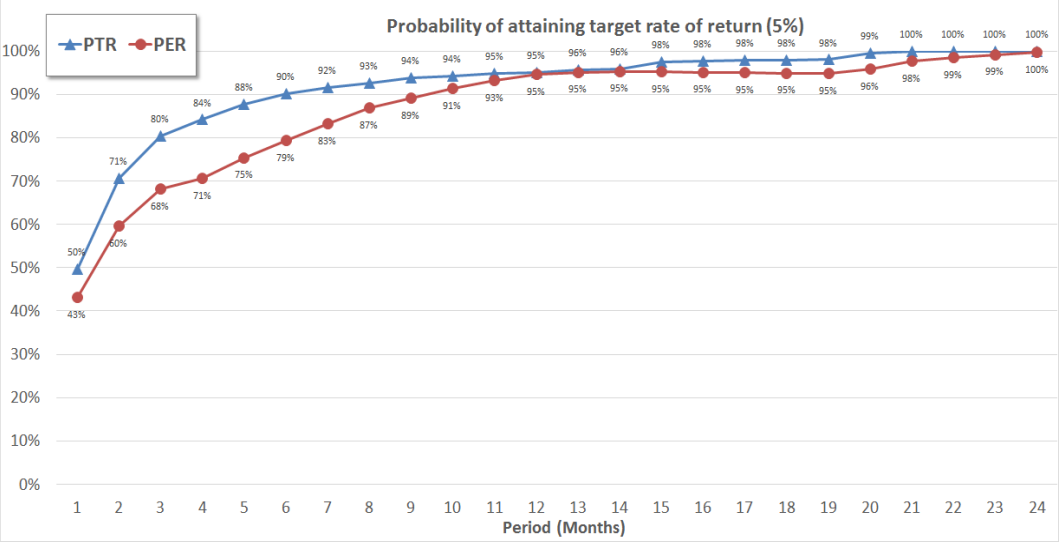


Figure 2 Probability of attaining target ROR(10%)

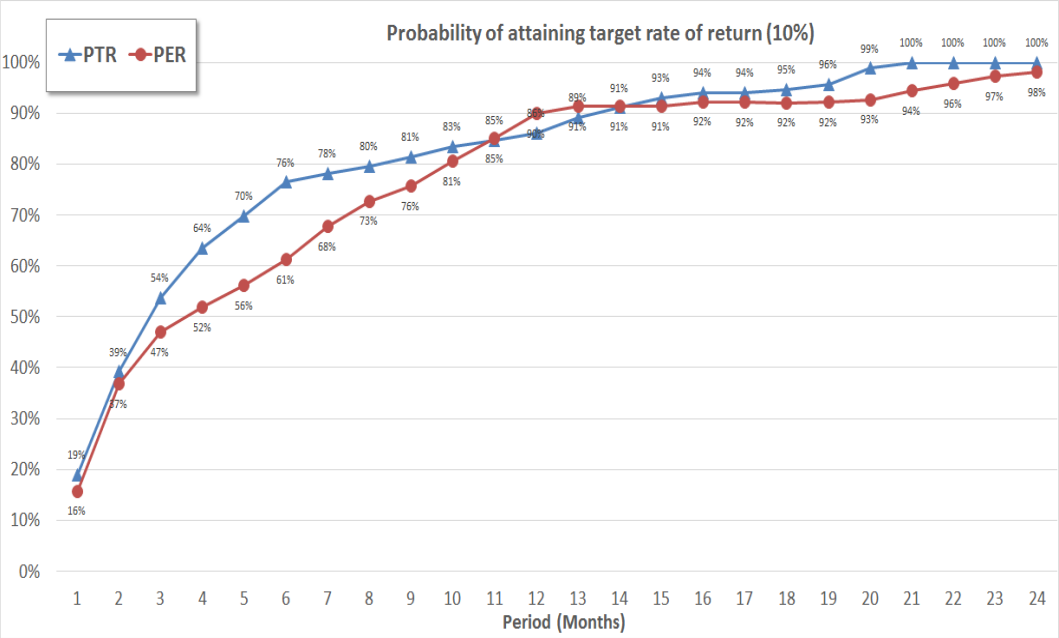


Figure 3 Probability of attaining target ROR(15%)

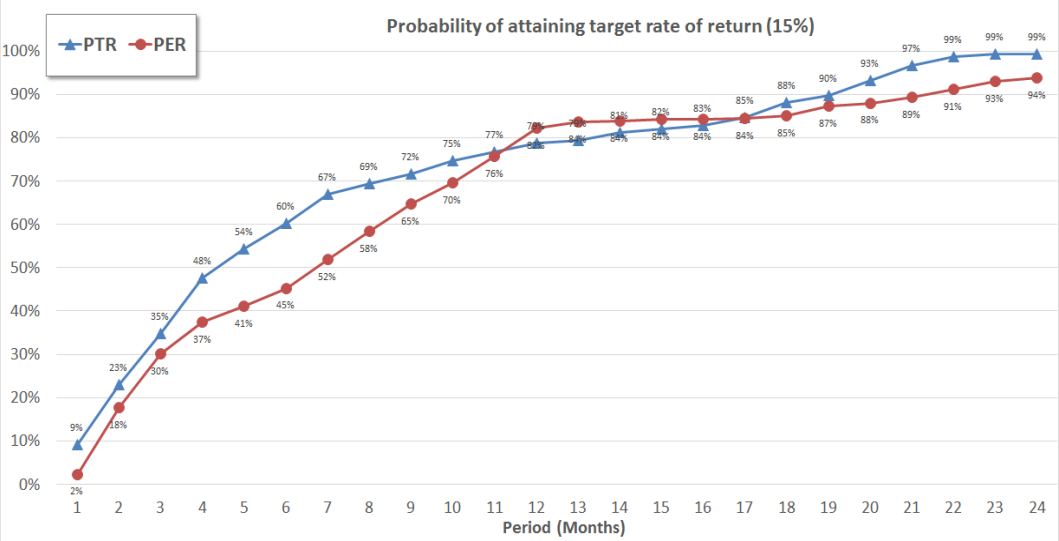


Figure 4 Probability of attaining target ROR(20%)

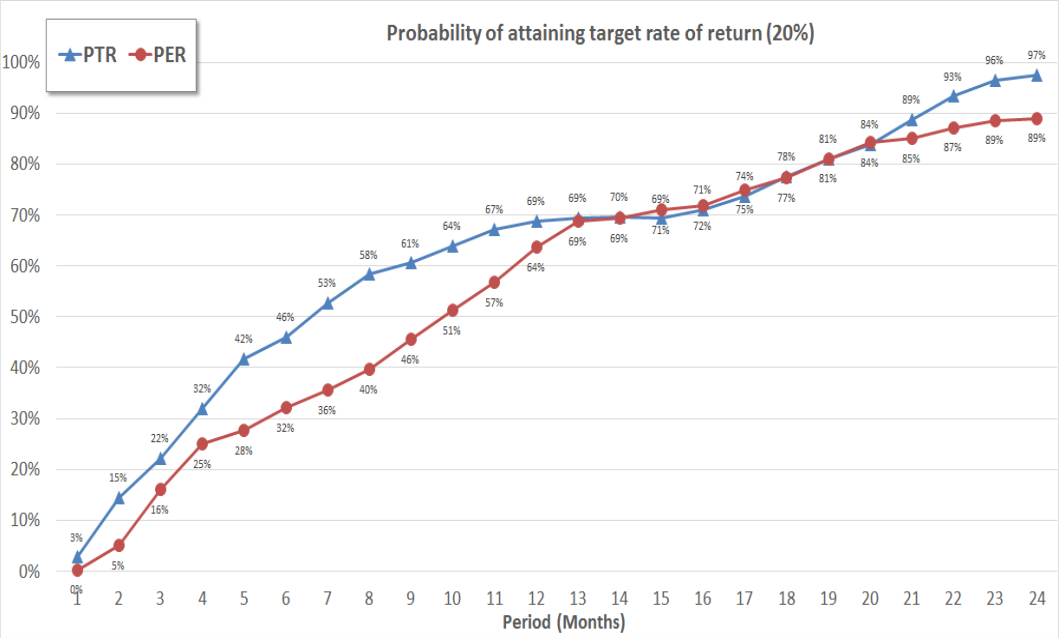
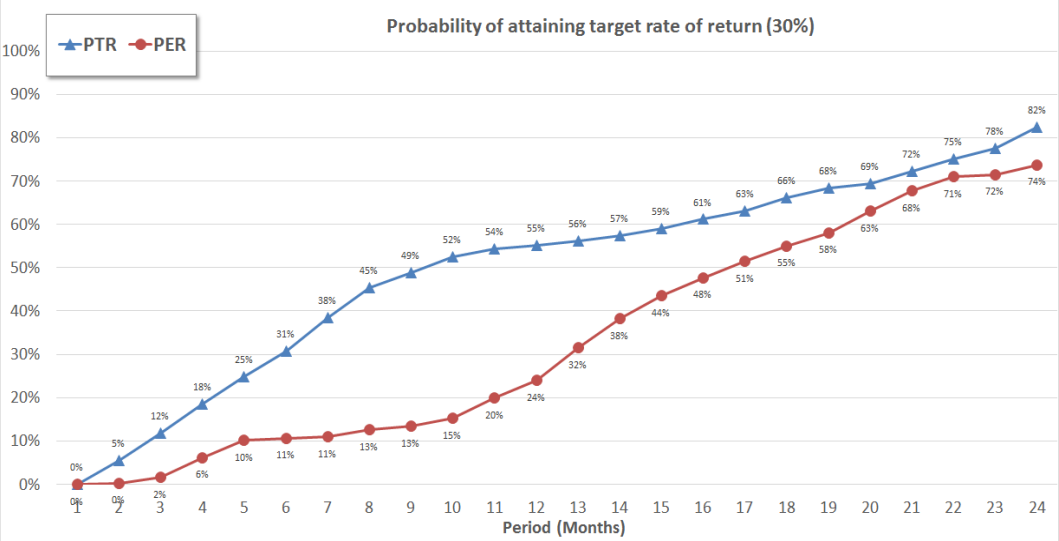


Figure 5 Probability of attaining target ROR(30%)



In Table 2, there are results of simulation when the target ROR is 40%, 50%, 60%, 70% and 80% are included. The results of these simulation are similar to those of 30%. The probability of attaining target goal of PTR portfolios is higher than PTR portfolios in every months. Figure 6, Figure 7, Figure 8, Figure 9 and Figure 10 shows the results of simulation when the target ROR is 40%, 50%, 60%, 70% and 80%.

Table 2 Probability of attaining target ROR (40% to 80%)

Period (Months)	Probability of attaining target ROR (portfolio consisted of bottom 20)									
	40%		50%		60%		70%		80%	
	PTR	PER	PTR	PER	PTR	PER	PTR	PER	PTR	PER
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.05	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00
4	0.09	0.00	0.04	0.00	0.03	0.00	0.01	0.00	0.00	0.00
5	0.16	0.02	0.08	0.00	0.03	0.00	0.02	0.00	0.02	0.00
6	0.20	0.02	0.12	0.00	0.06	0.00	0.03	0.00	0.01	0.00
7	0.27	0.03	0.16	0.00	0.08	0.00	0.05	0.00	0.01	0.00
8	0.33	0.02	0.21	0.00	0.12	0.00	0.07	0.00	0.02	0.00
9	0.39	0.02	0.27	0.00	0.17	0.00	0.12	0.00	0.04	0.00
10	0.41	0.04	0.31	0.01	0.22	0.00	0.17	0.00	0.07	0.00
11	0.46	0.04	0.36	0.01	0.26	0.00	0.19	0.00	0.09	0.00
12	0.48	0.07	0.40	0.02	0.34	0.00	0.26	0.00	0.13	0.00
13	0.51	0.11	0.44	0.05	0.37	0.00	0.30	0.00	0.18	0.00

14	0.55	0.16	0.47	0.07	0.41	0.01	0.32	0.00	0.19	0.00
15	0.56	0.24	0.49	0.09	0.43	0.01	0.36	0.00	0.23	0.00
16	0.59	0.28	0.49	0.14	0.44	0.06	0.36	0.01	0.26	0.00
17	0.59	0.33	0.49	0.18	0.43	0.10	0.36	0.04	0.26	0.01
18	0.60	0.37	0.49	0.23	0.44	0.15	0.37	0.06	0.26	0.01
19	0.61	0.39	0.49	0.25	0.44	0.17	0.37	0.08	0.28	0.03
20	0.62	0.43	0.52	0.27	0.45	0.18	0.39	0.10	0.29	0.03
21	0.64	0.48	0.52	0.30	0.46	0.20	0.41	0.10	0.31	0.03
22	0.66	0.52	0.53	0.35	0.46	0.22	0.42	0.11	0.34	0.04
23	0.68	0.58	0.57	0.41	0.49	0.27	0.42	0.15	0.35	0.05
24	0.70	0.63	0.60	0.46	0.55	0.29	0.47	0.17	0.36	0.06

Figure 6 Probability of attaining target ROR(40%)

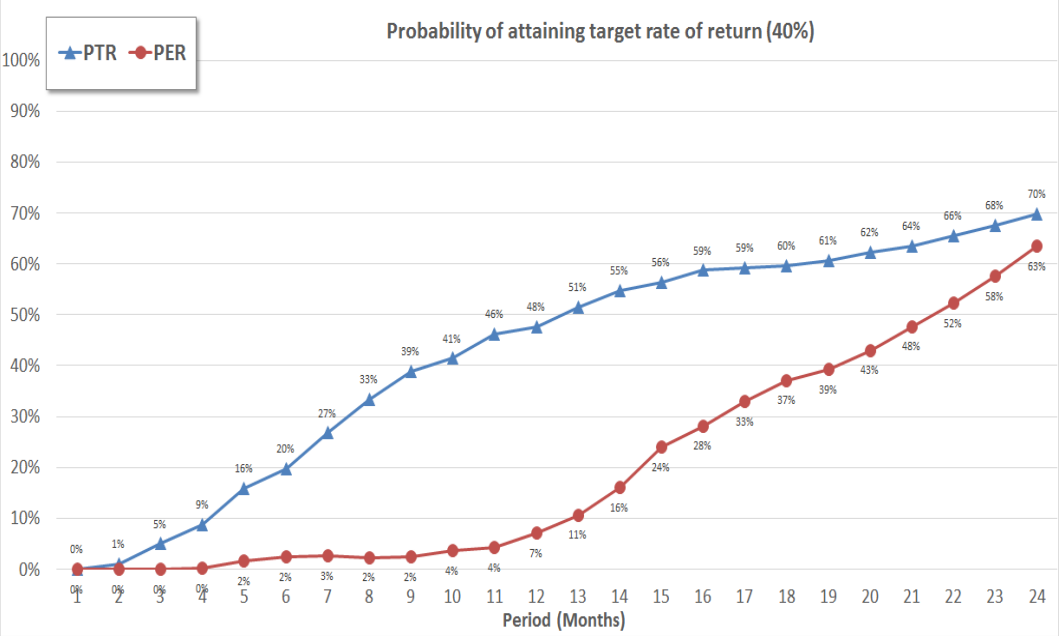


Figure 7 Probability of attaining target ROR(50%)

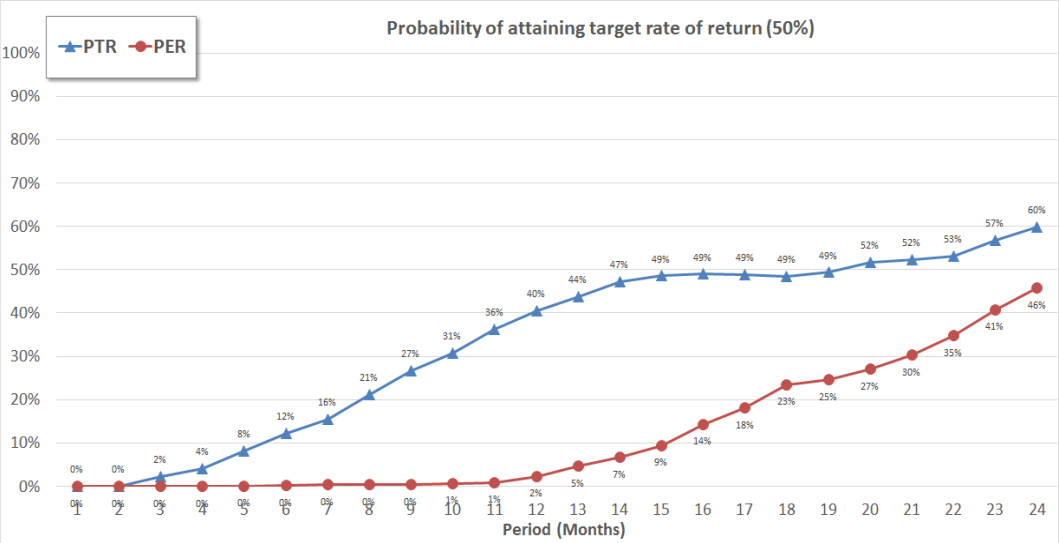


Figure 8 Probability of attaining target ROR(60%)

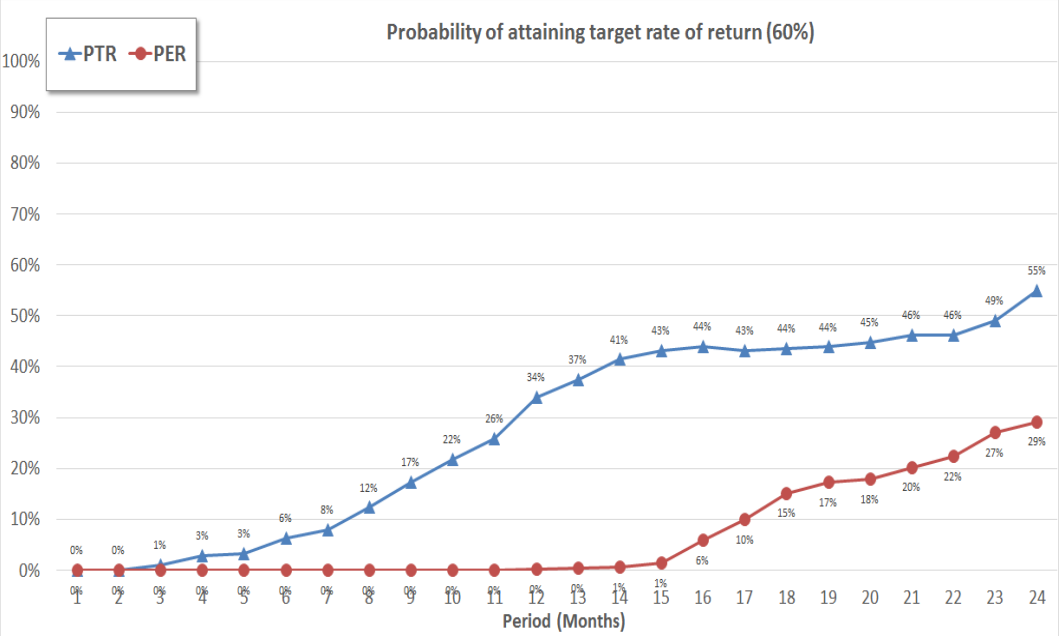


Figure 9 Probability of attaining target ROR(70%)

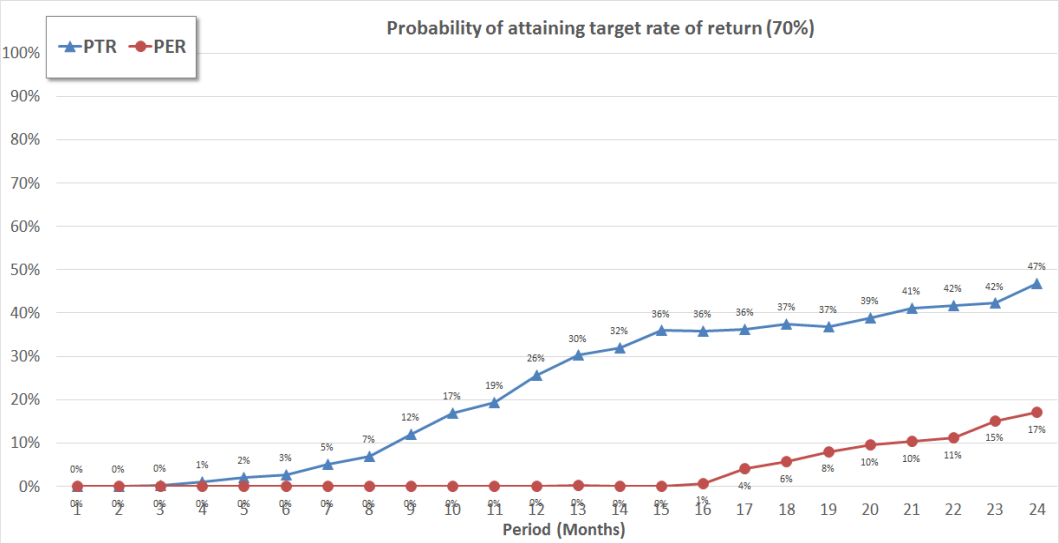
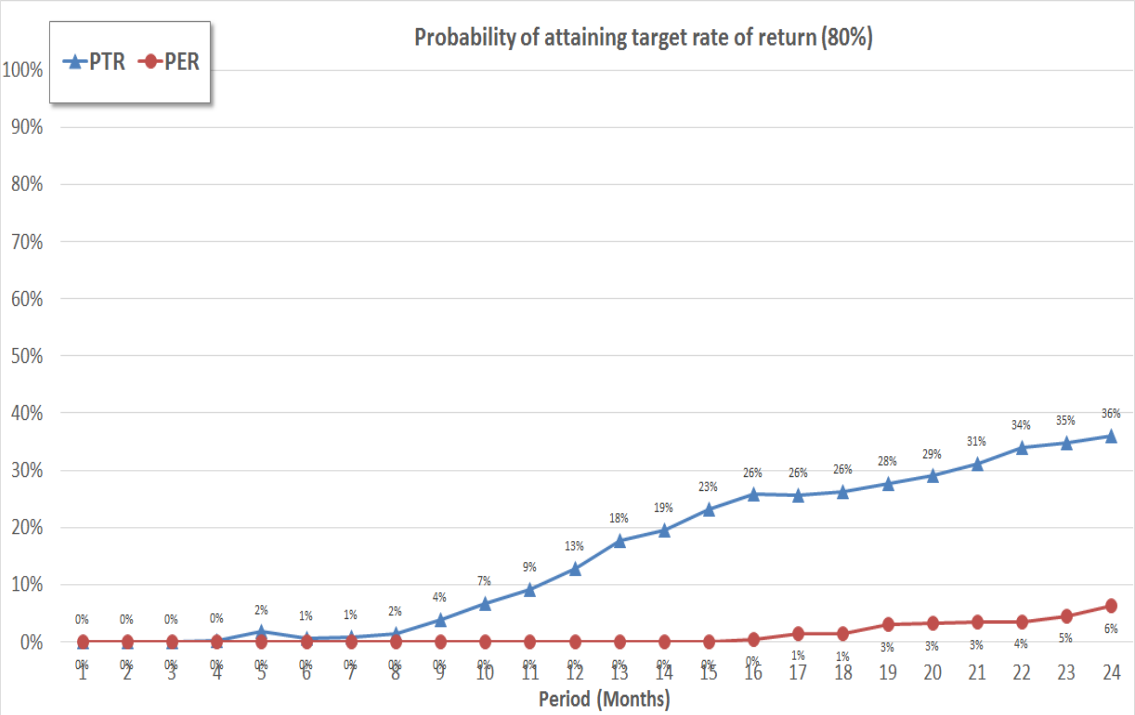


Figure 10 Probability of attaining target ROR(80%)



4.2. Results of simulation of PTR considering size effect

The performance of portfolios are different depend on the firm size. The result of simulation 4.1. mostly stays equal. It means that portfolios consist of low PTR stock items considering firm size meet the target ROR with higher probability than portfolios consist of low PER stock items in the same range. Table 3 shows the probability of attaining target ROR according to the firm size when the target ROR is 20%. The portfolio of range 4, firm size between 50 to 100 billion KRW results most high probability. The simulation results show that the portfolio of firm size between 50 to 100 billion KRW attain the target ROR with high probability when we hold it more than 10 to 12 months. And when we exclude range 1(which do not consider firm size), the range 4(firm size between 50 to 100 billion KRW) attain the goal with highest probability. It is presented in Figures below.

Table 3 Probability of attaining target ROR(20%) considering firm size

Target 20%	Firm size (billion)													
Period (Months)	∞ 0~		∞ 30~		30~50		50~100		100~200		200~400		400~2000	
	PTR	PER	PTR	PER	PTR	PER	PTR	PER	PTR	PER	PTR	PER	PTR	PER
1	0.03	0.00	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2	0.15	0.05	0.08	0.05	0.10	0.05	0.05	0.06	0.07	0.01	0.05	0.02	0.01	0.01
3	0.22	0.16	0.12	0.15	0.16	0.12	0.14	0.16	0.12	0.07	0.09	0.06	0.04	0.02
4	0.32	0.25	0.20	0.22	0.18	0.19	0.27	0.22	0.17	0.15	0.14	0.13	0.07	0.08
5	0.42	0.28	0.31	0.24	0.24	0.25	0.36	0.29	0.21	0.20	0.19	0.20	0.13	0.14
6	0.46	0.32	0.38	0.27	0.30	0.29	0.45	0.34	0.28	0.26	0.24	0.24	0.18	0.18
7	0.53	0.36	0.46	0.29	0.37	0.33	0.51	0.39	0.31	0.30	0.28	0.30	0.26	0.20
8	0.58	0.40	0.51	0.32	0.44	0.41	0.54	0.45	0.33	0.32	0.33	0.33	0.38	0.22
9	0.61	0.46	0.54	0.34	0.51	0.48	0.59	0.49	0.35	0.37	0.35	0.35	0.48	0.23
10	0.64	0.51	0.59	0.35	0.55	0.54	0.63	0.54	0.39	0.44	0.37	0.38	0.55	0.24
11	0.67	0.57	0.64	0.41	0.60	0.62	0.69	0.59	0.43	0.48	0.40	0.38	0.59	0.24
12	0.69	0.64	0.68	0.50	0.68	0.70	0.74	0.61	0.47	0.52	0.41	0.39	0.65	0.26
13	0.69	0.69	0.72	0.58	0.74	0.75	0.79	0.66	0.55	0.57	0.46	0.42	0.70	0.28
14	0.70	0.69	0.75	0.62	0.79	0.76	0.82	0.67	0.60	0.63	0.51	0.44	0.76	0.29
15	0.69	0.71	0.76	0.63	0.83	0.76	0.85	0.69	0.62	0.68	0.55	0.50	0.80	0.31
16	0.71	0.72	0.76	0.64	0.86	0.77	0.91	0.70	0.63	0.72	0.60	0.54	0.82	0.34
17	0.74	0.75	0.78	0.68	0.88	0.78	0.94	0.71	0.65	0.74	0.64	0.61	0.83	0.34
18	0.78	0.77	0.80	0.73	0.90	0.79	0.96	0.73	0.68	0.74	0.68	0.64	0.85	0.33
19	0.81	0.81	0.81	0.76	0.92	0.78	0.97	0.77	0.70	0.75	0.70	0.68	0.86	0.33
20	0.84	0.84	0.81	0.81	0.92	0.79	0.98	0.79	0.72	0.75	0.72	0.73	0.86	0.34
21	0.89	0.85	0.83	0.85	0.93	0.82	0.98	0.80	0.75	0.75	0.75	0.76	0.86	0.37
22	0.93	0.87	0.83	0.89	0.96	0.87	0.98	0.82	0.82	0.77	0.78	0.79	0.89	0.39
23	0.96	0.89	0.84	0.90	0.97	0.92	0.99	0.87	0.87	0.79	0.82	0.81	0.90	0.42
24	0.97	0.89	0.83	0.90	0.98	0.94	0.99	0.89	0.89	0.80	0.84	0.84	0.91	0.45

Figure 11 Probability of attaining target ROR(20%), PTR(size effect)

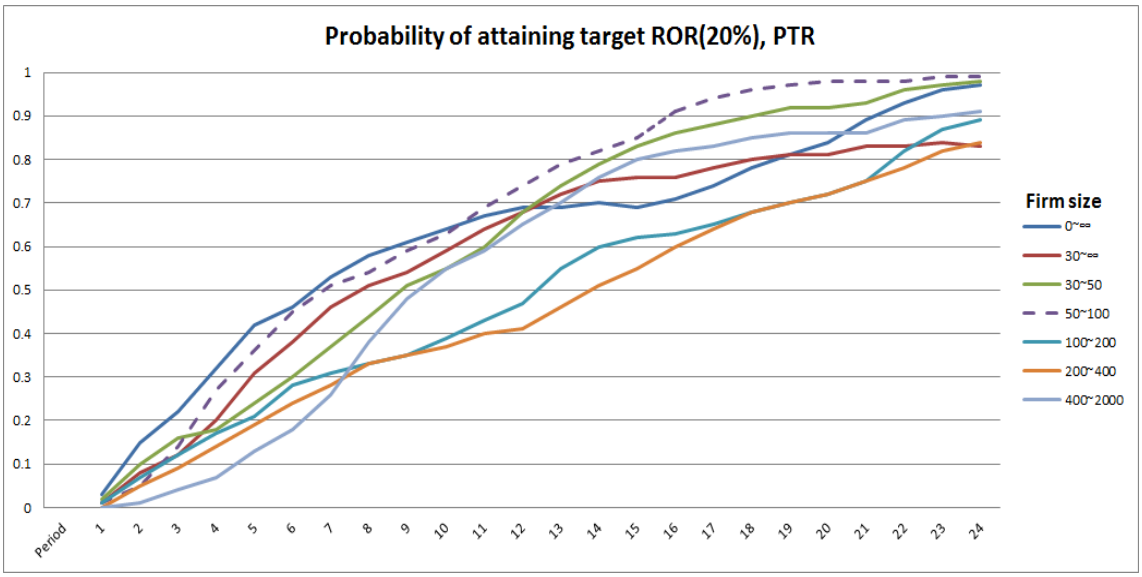


Table 4 Probability of attaining target ROR(30%) considering firm size

Target 30%	Firm size (billion)													
Period (Months)	∞ 0~		∞ 30~		30~50		50~100		100~200		200~400		400~2000	
	PTR	PER	PTR	PER	PTR	PER	PTR	PER	PTR	PER	PTR	PER	PTR	PER
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.05	0.00	0.00	0.00	0.03	0.02	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
3	0.12	0.02	0.06	0.01	0.11	0.05	0.04	0.02	0.05	0.00	0.03	0.00	0.00	0.00
4	0.18	0.06	0.07	0.06	0.13	0.09	0.07	0.06	0.06	0.00	0.06	0.01	0.01	0.00
5	0.25	0.10	0.11	0.11	0.13	0.11	0.12	0.08	0.07	0.03	0.06	0.02	0.02	0.01
6	0.31	0.11	0.18	0.11	0.15	0.13	0.19	0.12	0.07	0.04	0.08	0.03	0.02	0.02
7	0.38	0.11	0.25	0.10	0.21	0.14	0.28	0.14	0.10	0.05	0.10	0.03	0.03	0.06
8	0.45	0.13	0.33	0.10	0.24	0.17	0.34	0.17	0.12	0.06	0.15	0.12	0.07	0.10
9	0.49	0.13	0.38	0.10	0.27	0.19	0.40	0.20	0.14	0.08	0.18	0.18	0.10	0.13
10	0.52	0.15	0.41	0.10	0.29	0.22	0.44	0.23	0.17	0.10	0.21	0.23	0.17	0.15

11	0.54	0.20	0.45	0.10	0.32	0.28	0.48	0.26	0.18	0.14	0.23	0.26	0.21	0.15
12	0.55	0.24	0.46	0.13	0.35	0.33	0.53	0.34	0.19	0.19	0.28	0.27	0.28	0.16
13	0.56	0.32	0.52	0.20	0.42	0.41	0.61	0.39	0.22	0.24	0.32	0.30	0.32	0.16
14	0.57	0.38	0.56	0.27	0.47	0.52	0.69	0.43	0.29	0.29	0.37	0.31	0.34	0.18
15	0.59	0.44	0.58	0.33	0.53	0.56	0.73	0.45	0.33	0.38	0.40	0.33	0.36	0.20
16	0.61	0.48	0.58	0.37	0.59	0.58	0.75	0.47	0.36	0.44	0.44	0.36	0.39	0.24
17	0.63	0.51	0.59	0.38	0.65	0.63	0.79	0.49	0.40	0.49	0.47	0.39	0.44	0.25
18	0.66	0.55	0.61	0.40	0.68	0.66	0.84	0.52	0.44	0.52	0.52	0.44	0.46	0.26
19	0.68	0.58	0.65	0.45	0.73	0.70	0.86	0.52	0.47	0.53	0.56	0.48	0.48	0.26
20	0.69	0.63	0.67	0.52	0.75	0.72	0.88	0.53	0.49	0.55	0.61	0.50	0.50	0.27
21	0.72	0.68	0.70	0.57	0.75	0.73	0.92	0.56	0.55	0.54	0.63	0.54	0.53	0.28
22	0.75	0.71	0.75	0.61	0.78	0.77	0.92	0.57	0.58	0.54	0.66	0.57	0.55	0.29
23	0.78	0.72	0.75	0.65	0.84	0.80	0.94	0.59	0.64	0.55	0.68	0.62	0.56	0.31
24	0.82	0.74	0.76	0.71	0.86	0.83	0.95	0.61	0.70	0.56	0.74	0.64	0.56	0.34

Figure 12 Probability of attaining target ROR(30%), PTR(size effect)

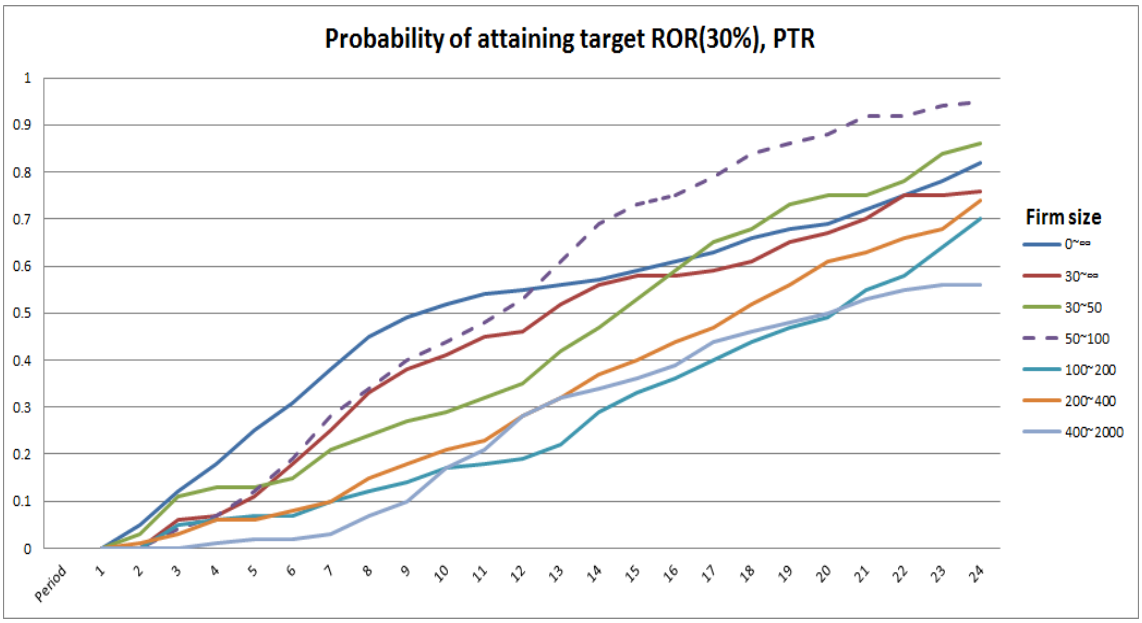
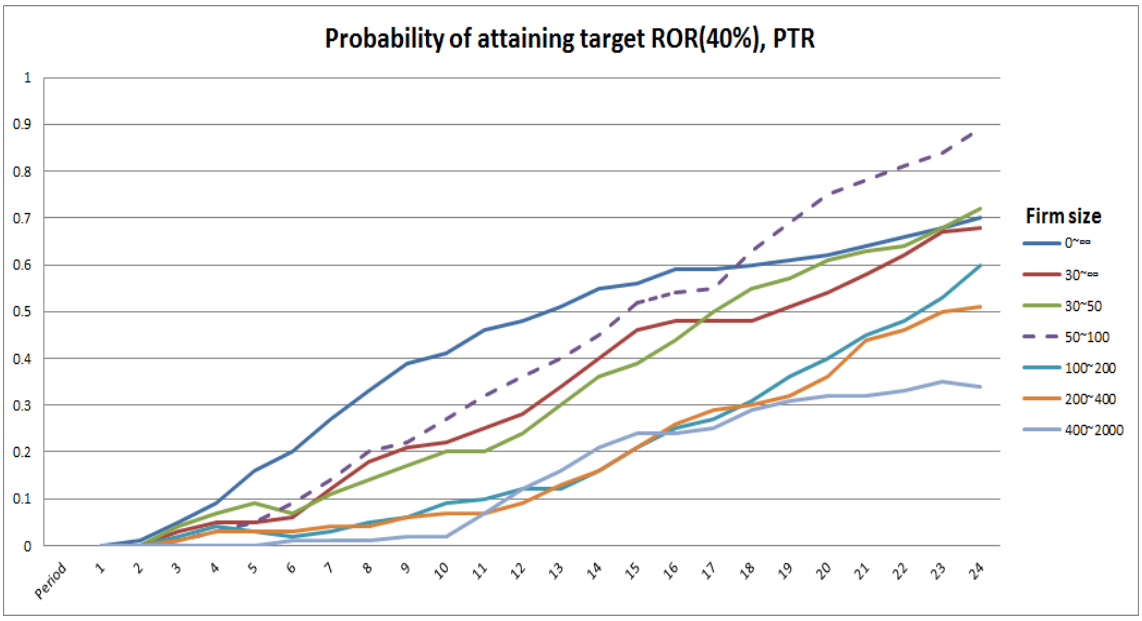


Table 5 Probability of attaining target ROR(40%) considering firm size

Target 40%	Firm size (billion)													
Period (Months)	∞ 0~		∞ 30~		30~50		50~100		100~200		200~400		400~2000	
	PTR	PER	PTR	PER	PTR	PER	PTR	PER	PTR	PER	PTR	PER	PTR	PER
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.05	0.00	0.03	0.00	0.04	0.01	0.01	0.00	0.02	0.00	0.01	0.00	0.00	0.00
4	0.09	0.00	0.05	0.00	0.07	0.03	0.03	0.01	0.04	0.00	0.03	0.00	0.00	0.00
5	0.16	0.02	0.05	0.01	0.09	0.04	0.05	0.02	0.03	0.00	0.03	0.00	0.00	0.00
6	0.20	0.02	0.06	0.02	0.07	0.07	0.09	0.03	0.02	0.00	0.03	0.00	0.01	0.00
7	0.27	0.03	0.12	0.02	0.11	0.09	0.14	0.04	0.03	0.00	0.04	0.00	0.01	0.00
8	0.33	0.02	0.18	0.02	0.14	0.09	0.20	0.04	0.05	0.01	0.04	0.02	0.01	0.01
9	0.39	0.02	0.21	0.01	0.17	0.09	0.22	0.06	0.06	0.03	0.06	0.06	0.02	0.03
10	0.41	0.04	0.22	0.01	0.20	0.09	0.27	0.08	0.09	0.04	0.07	0.08	0.02	0.05
11	0.46	0.04	0.25	0.02	0.20	0.12	0.32	0.10	0.10	0.06	0.07	0.09	0.07	0.07
12	0.48	0.07	0.28	0.03	0.24	0.17	0.36	0.14	0.12	0.07	0.09	0.10	0.12	0.10
13	0.51	0.11	0.34	0.07	0.30	0.19	0.40	0.18	0.12	0.08	0.13	0.11	0.16	0.11
14	0.55	0.16	0.40	0.10	0.36	0.26	0.45	0.22	0.16	0.10	0.16	0.13	0.21	0.11
15	0.56	0.24	0.46	0.15	0.39	0.39	0.52	0.24	0.21	0.14	0.21	0.15	0.24	0.11
16	0.59	0.28	0.48	0.16	0.44	0.45	0.54	0.27	0.25	0.18	0.26	0.16	0.24	0.12
17	0.59	0.33	0.48	0.18	0.50	0.51	0.55	0.31	0.27	0.20	0.29	0.20	0.25	0.14
18	0.60	0.37	0.48	0.20	0.55	0.55	0.63	0.36	0.31	0.22	0.30	0.23	0.29	0.16
19	0.61	0.39	0.51	0.22	0.57	0.60	0.69	0.39	0.36	0.24	0.32	0.25	0.31	0.17
20	0.62	0.43	0.54	0.25	0.61	0.63	0.75	0.42	0.40	0.27	0.36	0.27	0.32	0.18
21	0.64	0.48	0.58	0.31	0.63	0.65	0.78	0.44	0.45	0.29	0.44	0.29	0.32	0.18
22	0.66	0.52	0.62	0.34	0.64	0.68	0.81	0.46	0.48	0.28	0.46	0.31	0.33	0.19
23	0.68	0.58	0.67	0.39	0.68	0.72	0.84	0.48	0.53	0.27	0.50	0.32	0.35	0.19
24	0.70	0.63	0.68	0.47	0.72	0.74	0.89	0.50	0.60	0.27	0.51	0.35	0.34	0.20

Figure 13 Probability of attaining target ROR(40%), PTR(size effect)



Rolf W. Banz showed that on average, the common stock of small firms had higher returns than common stock of large firms. (the size effect) In this study, the results of long term investment show firm size between 50 to 100 billion attained target ROR with highest probability. But in short term investment, portfolios with no constraint show highest probability of attaining target ROR.

4.3. Comparing invest performance of PTR and KOSPI

Additionally, we analyzed results of actual investment of portfolios consisting of low PTR stock items. This investment is conducted by Wizdomain. The maximum investment period is 3 months. If the portfolio attaining the target ROR(5%) during this period, Wizdomain sell the portfolio. And if the portfolio do not attaining the target ROR during 3 months, they sell it at the end of this period. This actual investment started September 2015. So far the ROR of low PTR portfolio is higher than KOSPI and KOSDAQ bench mark. The result is shown in Table 6.

Table 6 Results of actual investment

Portfolio	Start	Sold	Investment Period(days)	ROR (%)	KOSPI BM(%)	KOSDAQ BM(%)
A	2015-09-01	2015-11-08	68	10.96	6.63	3.16
B	2015-11-09		25	2.35	3.14	1.91
C	2015-09-02	2015-12-04	93	4.00	3.09	1.14
D	2015-09-07	2015-12-04	88	4.00	2.22	3.45
E	2015-09-14	2015-12-04	81	4.55	0.49	-0.45
F	2015-09-21	2015-12-04	74	4.55	1.62	0.45

G	2015-12-04		-	0.00		
H	2015-12-04		-	0.00		
I	2015-12-04		-	-0.23		
J	2015-09-25		69	-1.53	1.62	0.45
K	2015-09-30	2015-10-20	20	4.50	3.90	1.88
L	2015-10-20		44	3.10	0.59	1.07
M	2015-10-05		59	-0.46	-0.19	-0.78
N	2015-10-30	2015-12-02	32	4.48	-1.74	-0.66

5. Conclusion

In this paper an attempt was made to determine the relationship between PTR and investment performance of portfolios by simulation. The low PER portfolios and low PTR portfolios both attained the target ROR in high probability. During the period January 2010−July 2015, the low PTR portfolios seem to have, on average, attained target ROR in higher probability than the low PER portfolios. These results suggest that PTR can be used to consist a portfolio as an indicator of future investment performance.

The evidence presented in this study suggests that the size effect exists in portfolios consist of low PTR stock items. This size effect is different from R. W. Banz(1981). He finds that the common stock of small firms had, on average, higher risk adjusted returns. But in this study, we found that portfolios consisted of stocks from market value between 50 to 100 billion KRW mostly resulted higher rate of return than others. And concluded there is a size effect in PTR portfolios.

We suggest one another indicator PTR, which evaluates the firm's technology value. The technology value includes firm's patented R&D output and patents the firm possessed by purchase. Accordingly, low PTR means that the value of firm's R&D activity is not fully reflected in security prices and investing portfolios with low PTR stocks will result in high investment performance. In the simulation of long term investment, there was a size effect. But we do not find out clear explanation for this result. Further research should consider the relationship between size and other related factors.

The findings of this study confirmed the PTR portfolios outperform the PER portfolios. Therefore managers should consider PTR and technology value when they make investment decisions. Especially, firms between market value of 50 to 100 billion KRW should consider PTR. Due to the size effect, considering technology value is more proper for those firms.

Limitation of this research is there can be unknown factors correlate with patent value. In addition to this, we only considered the probability of getting target return and did not consider the

probability of loss. By analyzing actual investment results, we included both probability of win and loss. However, this investment is started from September 2015. Afterwards additional investment analysis is needed. And there is no theoretical foundation for size effect. We do not know why is firm size of that range showed highest return. Further research should consider the size and other patent value related factors.

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국문 초록

PTR 에 따른 주식의 투자성과 연구

-KOSPI 와 KOSDAQ 상장주 투자 시뮬레이션

전가영

경영학과 생산관리 전공

서울대학교 대학원

기업의 연구 개발이 투자활동에 해당한다는 것은 널리 받아들여지고 있다. 이 투자활동의 결과물은 기업의 시장가치에 반영되어야한다. Bosworth, D 와 Rogers, M 은 연구개발과 특허 활동이 기업의 시장가치와 유의적인 양의 관계가 있다는 것을 그들의 연구에서 보였다. 또한, K-C, Chang et al.(2012)은 기업이 보유한 특허의 수와 기업 성과의 관계에 대한 연구에서 특허가 널리 이용되고 있다는 것을 보였다.

특허 성과와 기업 성과의 관계에 관한 연구에서는 많은 학자들이 특허 인용 지수와 기업의 시장가치 간에 양의 관계가 있다는 것을 확인했다.

본 논문에서는 기업의 기술 가치를 평가하는 새로운 지표인 PTR 을 제시한다. 여기에서 기술 가치는 기업 연구개발 활동의 결과물인 특허와 기업이 매수를 통해 보유하고 있는 특허를 모두 포함한다. 따라서 PTR 이 낮다는 것은 기업의 연구개발 활동이 주가에 완전히 반영되지 않았다는 것을 의미하고, PTR 이 낮은 주식으로 이루어진 포트폴리오에 투자하여 높은 투자 성과를 얻을 수 있었다. 시뮬레이션 결과에 따르면 장기 투자의 경우에는 규모 효과가 있었다.

본 논문의 시뮬레이션 결과, PTR 과 높은 상관관계가 있는 주식 그룹에서 PTR 이 낮은 주식으로 구성된 포트폴리오가 PER 이 낮은 주식으로 구성된 포트폴리오보다 더 높은 성과를 보였다. 그러므로 경영자들은 투자의사결정을 할 때 PTR 과 기술 가치를 고려한다면 보다 높은 투자 성과를 얻을 수 있을 것이다. 특히 기업 시장 가치가 500 억 원에서 1000 억 원 사이에 해당하는 기업에 투자할 때에는 PTR 을 고려해야 한다. 시뮬레이션 결과, 규모 효과 때문에 이 범위에 해당하는 기업의 경우 기술 가치를 고려하는 것이 더 적절하였다.

주요어 : 특허 가치; 특허-기술 비율; 연구개발 성과지표; 특허 가치 지표

학번 : 2014-20441